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THE INSTITUTE OF PETROLEUM

AN Ordinary General Meeting of the Institute of Petroleum was held at Manson House, 26 Portland Place, London, W.1, on Wednesday, February 14, 1951, the President, C. A. P. Southwell, M.C., B.Sc., in the Chair.

The Minutes of the preceding meeting, held on January 10, 1951, were read, confirmed, and signed.

THE GENERAL SECRETARY (D. A. Hough) announced the elections to membership since the previous meeting.

THE PRESIDENT, introducing Mr Thorpe and inviting him to present his paper, said: Mr Thorpe, who is Chairman of the Wax Sub-Committee of the Institute's Standardization Committee, has held a long and varied experience of petroleum waxes, both in Great Britain and in America.

Mr Thorpe presented the following paper.

PETROLEUM WAXES: THEIR USE AND EVALUATION FOR PAPER PACKAGING

By T. C. G. THORPE (Fellow) *

SUMMARY

Petroleum wax is a vital material in the manufacture of paper and paperboard packaging materials. Commercial technology relating to the evaluation of such waxes is confused. It is desirable that the oil industry and the package manufacturers should co-operate more closely in order that tests to evaluate waxes should be standardized.

This paper reviews the usage, attempts to indicate the wax properties of greatest importance in packaging, and illustrates current practices in assessing these properties, in the hope that it will lead to closer co-operation between wax producers and wax users to the benefit of packaging.

GENERAL

IN this age of rapidly developing industrial life humanity is frequently subjected to explanation, and even apologies, from philosophers, writers, and orators on the underlying reason for man's insistent urge to develop and increase his mechanical efficiency. Many of these philosophers have concluded that man's intention is to improve whatever his notion of "standard of living" may be. Currently this means that he wishes to enjoy more and more of those goods which ease his labour, help his recreation, and improve his diet. His prospects are completely dependent upon the availability of the goods his industry produces, and this availability is dependent upon easy and cheap transport.

Packaging has made a vast contribution to man's search for better living. Good packaging has permitted the transport of goods from regions of high and cheap productivity to areas where they are needed. In fact, without good packaging, man's standard of living would fall immeasurably.

The vast and ever-expanding use of packages calls upon an enormous

* Esso Petroleum Co. Ltd.

range of materials, but high, very high among these materials, stands paper and paper-board. Paper is used in packaging because it is the cheapest and most readily available self-supporting film. It is manufactured in a wide variety of qualities, most of which take printing very readily, but it has at least one very great disadvantage, it is porous, and has very little resistance to the passage of vapours, particularly moisture vapours. Furthermore, most papers readily absorb moisture with disastrous decrease in their tensile or rupture strength. Many natural and synthetic waxes and resins can be incorporated in, or applied to the paper to offset these disadvantages, but the cheapest and most readily available are the petroleum products, wax and asphaltic bitumen.

The relative costs of a selection of materials used in proofing paper are given in Table I. In all cases the materials are more difficult, and hence more expensive, to apply to paper than is wax.

TABLE I

Relative Cost of Coating Materials *

Asphaltic bitumen	8
Paraffin wax	70
Microcrystalline wax	110
G.R.S.	200
Butyl rubbers	200
Polythenes	350
Polybutenes	450

* Based on approximate selling price per ton in 1950.

There was a time when petroleum wax was regarded by its producer, the oil industry, as one of its minor products, which found a ready market with the candle manufacturers. Over the years the great versatility of wax became increasingly apparent, until to-day it can claim to be the most versatile product of the oil industry.

Most people realize that their candles and waxed tapers consist mainly of paraffin wax; they probably know too that it is waxed-paper wrappings that preserve their breakfast cereal, their bread or their toffee and chocolate. They may appreciate that it is wax that waterproofs and strengthens their milk and ice-cream cartons. They are probably mildly aware of the debt they owe to wax for their shoe, furniture, and floor polishes.

What many people do not realize is that wax is the vital constituent for the waterproofing of many fabrics, even raincoats, for the impregnating of matches, and for the insulation of much electrical apparatus such as cables, condensers, and batteries. They do not realize that it is largely wax which makes their leather goods soft and flexible, that wax is a major ingredient of cosmetics, hand creams, and ointments.

The long catalogue of diverse uses for wax could go indefinitely through such further applications as the almost-invisible films that protect sheets of steel or tiny precision mechanisms from corrosion, and fruit and vegetables from shrinkage and waste, to the plucking of chickens.

It is fortunate that as wax use has expanded so also has its production. This is not a coincidence. Man's insistent urge to increased industrial activity has led to ever-increasing demands for petroleum, and as most crude oil contains wax which can readily be extracted, the potential availability of wax has increased in step with demand. Incidentally, although

the oil industry is happy to find this increasing market for wax, it will never be seriously embarrassed by a surplus, because wax is not only a most useful product for use as such, but it is also an excellent raw material for various syntheses and a valuable feed stock for oil refineries making gasoline. At the present time, quite apart from its use as a raw material in the manufacture of detergents, fatty acid, and chlorinated compounds, or by the oil industry itself, the total world production and consumption of petroleum waxes, excluding Russian controlled areas, is over 600,000 long tons annually.

Although the total world consumption of petroleum wax is only about 0·1 per cent of the crude petroleum processed in refineries, it is nevertheless a very important product, and its specialized properties for a diversity of uses makes it a valuable product of increasing concern to the oil industry.

The value of wax can be illustrated by Table II which compares the value of wax to the petroleum industry with its other major products.

TABLE II

*Relative Value of Petroleum Products**

* Based upon refiners' average selling price (exclusive of taxes) in 1950.

The major usages are illustrated in Table III, which also draws a comparison with the national usage in the U.S.A., which uses about 350,000 tons per year, and the United Kingdom, whose consumption is 40,000 to 50,000 tons per year. That of the United Kingdom is probably fairly representative of the usage throughout Europe.

The figures given include refined paraffin, scale, and microcrystalline waxes.

TABLE III

Industry	Estimated percentage of total consumption used in industry	
	U.S.A.	U.K.
Packaging *	57	25
Candle	8	35
Polish	8	10
Electrical	2	10
Rubber	1	2
Leather	5	2
Match	5	2

* Includes application to paper, board, cartons, and foils.

It will be seen that the dominant usage of wax in the U.S.A. is for packaging, whilst in the United Kingdom the major use is in candle manufacture. It does not require a great deal of imagination to realize that with increasing electrification schemes throughout the world, candle consumption

will tend to decrease. At the same time it should be appreciated that so far as packaging is concerned, the U.S.A. are in advance of the rest of the world, and it is logical to assume that American trends in packaging can be taken as a good indication of future world trends. For this reason a substantial portion of this paper is based on American practice and experience with the use of wax in packaging. To illustrate further the American lead, it can be calculated that Americans use for packaging about 3·0 lb of wax per head of population per year, whilst in the United Kingdom the figure is about 0·5 lb. When it is realized that the amount of wax per head of population is still rapidly increasing in the U.S.A., the great expansion that can be expected outside the U.S.A. when industrial nations are free from restrictions in supplies of paper and wax can be appreciated.

In view of the great importance of wax in packaging, it is surprising that so little has been published on the technology of wax in this usage. Excellent papers have been produced on the constitution of waxes, on their chemical nature, and their physical characteristics as seen by the research worker. Much has been published on their manufacture, but the literature relating to their commercial technology is very sparse. Although many interested in the wax-using industries and in the oil industry apply tests in an endeavour to obtain commercial evaluation of the wax, there has been a reluctance to publish the methods used. Whether this reluctance is due to a desire to keep testing methods secret for commercial reasons, or whether it is because the users of the tests are uncertain of the significance or interpretation of their tests, we have never been sure. It is probably a mixture of both reasons.

It is the author's intention to devote the greater part of this paper to a review of the characteristics of waxes that dominate their use in packaging, and to indicate those methods that he has found to be most popular in assessing such characteristics.

This is done in the hope that it will lead to closer co-operation between the users of wax and the oil industry, with a resultant improvement in wax-packaging standards.

Before proceeding it is essential to be quite clear on what is meant by petroleum waxes. Petroleum waxes are those hydrocarbons which exist to a greater or lesser extent in all crude petroleums, and which, when removed from petroleum, are solid and crystalline at normal atmospheric temperatures.

Commercially such waxes are placed in two groups :—

1. *Paraffin Waxes Including Paraffin Scale*

These waxes are usually white or pale yellow crystalline materials extracted from distillates in various boiling ranges, but usually within 200° to 350° C at 10 mm. Such waxes have melting points in the order of 90° to 150° F. They consist mainly of normal paraffins, and their molecular weights range from 225 to 450. Commercially these waxes have oil contents varying from less than 0·1 to as high as 10 per cent, although refined paraffin is generally less than 1·0 per cent. According to the degree of refinement they receive, they may also have present complex oxidized hydrocarbons, which tend to give less highly refined products a yellow colour.

2. *Microcrystalline Waxes*

These waxes can be white, yellow, brown, or black, depending upon the degree of refinement they have received. They can be plastic or hard and brittle. The plastic varieties are not obviously crystalline, and hence the term "amorphous" has been incorrectly applied to them. The term "microcrystalline" has been applied to them because they are of smaller crystal size than are the paraffin waxes. They are extracted from high-boiling-point residual lubricating oils, or from tank-bottom waxes. These latter are soft petrolatums which are precipitated from crude and topped crude during storage in tanks. Some microcrystalline waxes are manufactured from very high-boiling-point distillates such as are sometimes termed distillate or overhead cylinder oils. These waxes are often rather more crystalline than the waxes from residues. The microcrystalline waxes have melting points which generally fall in the range 140° to 200° F. They contain considerable quantities of hydrocarbons other than normal paraffin, and their molecular weights range from 450 to 1000. Commercially microcrystalline waxes have oil contents varying from 0·5 to 15 per cent.

Some typical physical characteristics of petroleum waxes are given in Table IV. Other characteristics will be found in the appropriate section.

TABLE IV

Characteristic	Refined paraffin wax	Microcrystalline wax
Melting point:		
I.P. 55/44; ASTM D87–42	90°–150° F	—
ASTM D127–49	—	140°–200° F
Colour	White	White, yellow, brown, or black
Flash point, I.P. 34/47; ASTM D93–46	>350° F	>450° F
Viscosity:		
150° F	5·4–8·2 cs	—
210° F	2·4–4·3	10·0–20·0 cs
300° F	1·3–2·2	4·5– 7·8
Boiling point:		
50% Distilled at 10 mm. pressure	225°–300° C	—
„ „ 1 mm. „	—	250°–350° C
Refractive index at 75° C	1·428–1·432	1·44–1·46
Molecular weight	225–450	450–1000
Oil content, ASTM D721–47	<1·0%	Up to 15%
Penetration, I.P. 49/46; ASTM D5–25; 100 g, 5 sec, 25° C.	12–25 *	2–75

* See section discussing wax hardness tests.

It is with reluctance that the author has yielded to general commercial practice in grouping waxes as above. A much more logical grouping and definition was published by the Institute of Petroleum in 1943 * but did not receive the attention it warranted. Briefly the Institute of Petroleum recommended and defined the following groups:—

1. *Paraffin*, which was subdivided into—

(a) *Refined paraffin wax.*

(b) *Scale wax*, which is a paraffin wax of higher oil content and less highly refined than (a).

* *J. Inst. Pet.*, 1943, **29**, 361–3.

2. *Petrolatum*, which was subdivided into—

   (a) *Petrolatum wax*, which is the plastic variety of what has been referred to above as microcrystalline waxes.

   (b) *Petroleum jelly*, which is really a petrolatum wax of high oil content.

3. *Petroleum Ceresins*, which are regarded as the brittle microcrystalline waxes, usually of high melting point, i.e., above 160° F.

Fig. 1 gives a diagrammatic indication of wax production. The process is varied according to economic conditions, type of wax and oil to be processed, and the quality of the wax to be produced. When producing microcrystalline wax from tank-bottom wax the process starts at the petrolatum or petroleum-jelly stage.

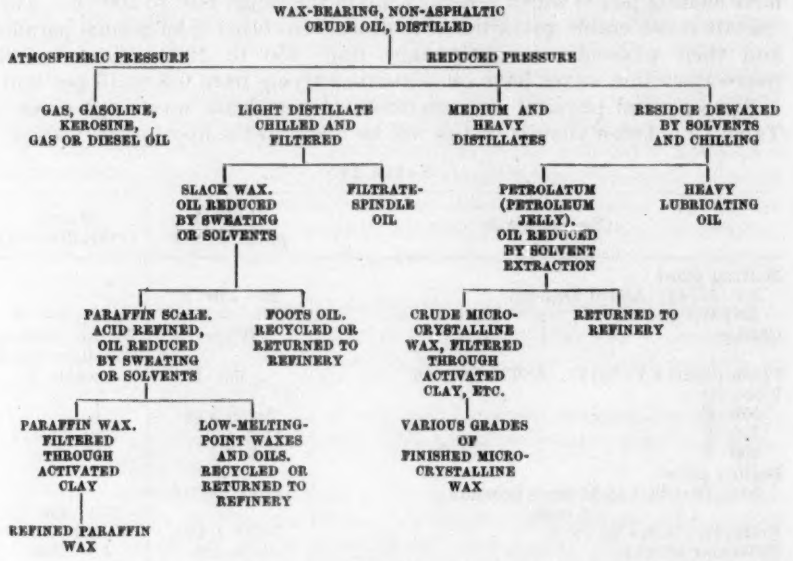
WAX-BEARING, NON-ASPHALTIC CRUDE OIL, DISTILLED
ATMOSPHERIC PRESSURE
REDUCED PRESSURE
GAS, GASOLINE, KEROSINE, GAS OR DIESEL OIL
LIGHT DISTILLATE CHILLED AND FILTERED
MEDIUM AND HEAVY DISTILLATES
RESIDUE DEWAXED BY SOLVENTS AND CHILLING
SLACK WAX. OIL REDUCED BY SWEATING OR SOLVENTS
FILTRATE-SPINDLE OIL
PETROLATUM (PETROLEUM JELLY). OIL REDUCED BY SOLVENT EXTRACTION
HEAVY LUBRICATING OIL
PARAFFIN SCALE. ACID REFINED, OIL REDUCED BY SWEATING OR SOLVENTS
FOOTS OIL. RECYCLED OR RETURNED TO REFINERY
CRUDE MICRO-CRYSTALLINE WAX, FILTERED THROUGH ACTIVATED CLAY, ETC.
RETURNED TO REFINERY
PARAFFIN WAX. FILTERED THROUGH ACTIVATED CLAY
LOW-MELTING-POINT WAXES AND OILS. RECYCLED OR RETURNED TO REFINERY
VARIOUS GRADES OF FINISHED MICRO-CRYSTALLINE WAX
REFINED PARAFFIN WAX

FIG. 1

DIAGRAMMATIC INDICATION OF WAX PRODUCTION

THE USE OF PETROLEUM WAXES IN PAPER PACKAGING

Paper and paper-board are the most widely used packing materials, but for many purposes they are not ideal because they are not waterproof. The lack of waterproofness not only means that the moisture can get to whatever may be inside the paper but also the water-wetted paper loses its strength and collapses. Paper or paper-board is simply a mass of cellulose fibres packed tightly together and sometimes bound with what is often a water-soluble sizing, and when necessary made to a prescribed density by the incorporation of inorganic fillers. One can readily imagine that many minute openings exist between the lattice of cellulose fibres, and it follows that the paper will offer even less resistance to moisture vapours than to water.

Waxing overcomes this weakness of paper and paper-board; according to the process used, the wax can be made to fill up the empty spaces between the cellulose fibres without leaving a very waxy surface (this is called "dry waxing," and is virtually an impregnation of the paper with wax), or the paper can be coated with a definite surface layer of wax. Many paper-waxing processes are a combination of both principles.

The art of paper waxing is very intricate and calls for a very high degree of precision. The adjustments of modern machines are so delicate that one can allow very thin paper to go through them and just receive a coating on one side without allowing any wax to penetrate right through, or one can allow the paper to be completely impregnated with or without a surface coating of wax.

Although by far the greatest quantity of paper is waxed with paraffin wax, there is a rapidly increasing manufacture of laminated paper in which a film of flexible slightly tacky microcrystalline wax is sandwiched between two sheets of paper or between paper and various foils. The resultant paper is very moisture-vapour-proof, and can be further improved by an orthodox wax coating.

In addition to its essential function of waterproofing, paraffin wax owes its great popularity as a paper-treating medium to several other properties. It is readily melted to give a fluid of low viscosity, in which form it is well adapted to coating and impregnating processes, furthermore, this property of ready melting lends itself to the heat sealing of waxed-paper packaging. Wax can be colourless, odourless, and tasteless, and these properties are essential for a material which is so frequently used for food wrapping.

The waxed-paper manufacturer does not, of course, rest satisfied when he is simply provided with a wax to waterproof his paper, he has several other more detailed requirements which are considered later.

Application of Wax to Paper and Cartons

Wax is applied to paper and paper-board by several methods, the most important of which are reviewed below.

1. *Paper Waxing*

Almost all paper is waxed by a continuous process, in which a system of rollers feeds the paper through a wax-bath. The wax-bath is usually rectangular and double-bottomed and constructed of steel. The upper part contains the wax, and steam circulates in the double bottom. Normally wax-tanks contain about 500 lb of wax. The pressure on the rolls, the wax temperature, the paper speed, and the rate of cooling of the waxed paper are all adjustable, and are varied according to requirements. Some typical paper-waxing processes are illustrated diagrammatically in Figs. 2 and 3.

Heavy paper stocks require higher wax contents, which are obtained by using comparatively soft rubber-squeeze rolls, often in combination with a relatively high wax temperature and a low paper speed. Lighter papers are coated with smaller quantities of wax, by using harder rubber-squeeze rolls, and higher paper speeds. Wire-wound rolls are sometimes used to control the amount of wax applied to the paper, and in this case the gauge of the wire controls the quantity of wax applied.

High gloss is desired by most waxed-paper manufacturers, and one

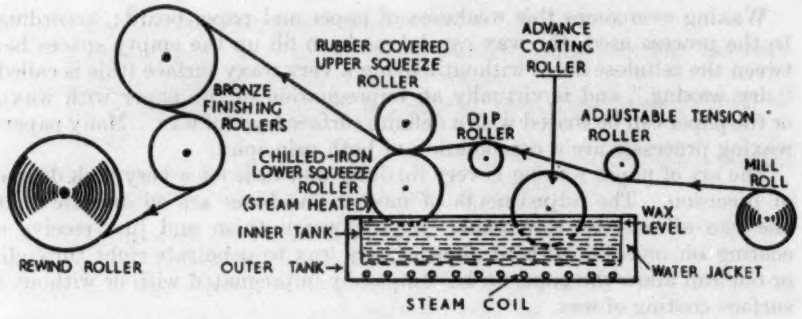

FIG. 2

SQUEEZE PROCESS COATING (ONE SIDE ONLY)

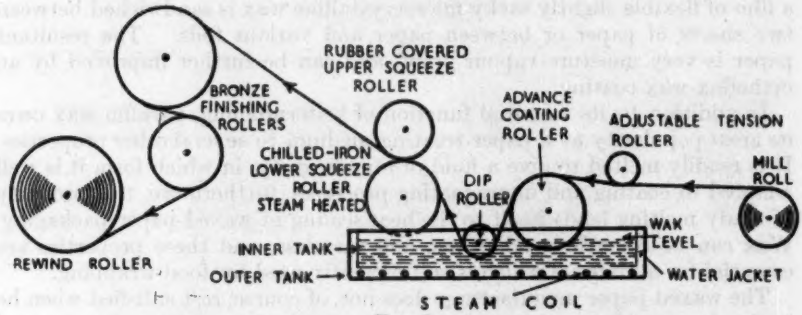

FIG. 3

SQUEEZE PROCESS COATING (BOTH SIDES)

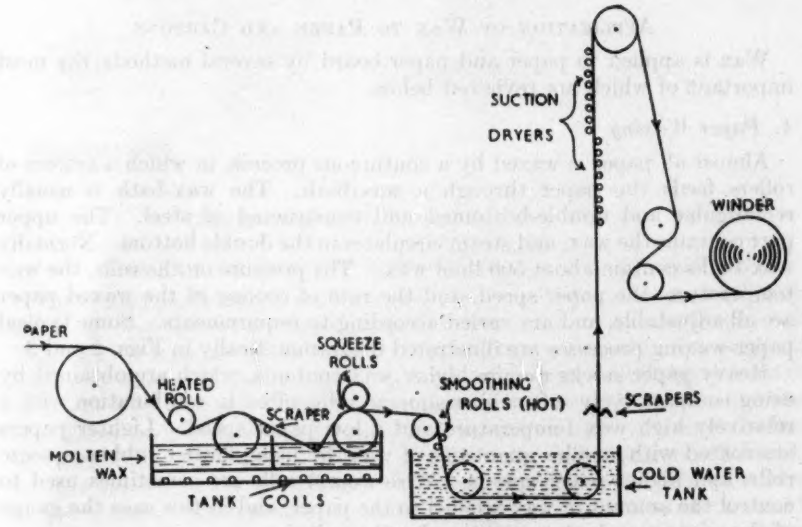

FIG. 4

WET WAXING PROCESS USING WATER-BATH

method of achieving success is by the cold-brine cooling of the highly polished bronze finishing rollers. The sudden cooling of the wax coating as it passes over these rollers and their polishing action results in a smooth glossy surface. Another method which has found favour for high-gloss production shock-cools the waxed paper by passing it through a cold-water tank. This process is illustrated in Fig. 4.

When it is desirable to have little wax on the paper surface, the finishing rolls are heated with steam, thus " ironing " the wax into the paper. This is called " hot waxing," and the paper is said to be dry-waxed.

Paper waxing is carried out at speeds ranging from 300 ft/min for heavy paper requiring heavy waxing to speeds of well over 1000 ft/min for light dry-waxed papers. Some manufacturers have in fact claimed speeds as high as 1750 ft/min for dry-waxed paper.

Waxing temperatures are generally controlled at as low a temperature as is consistent with sufficient impregnation, and as a general rule temperatures are in the order of 160° to 180° F. Higher temperatures lead to wax oxidation with subsequent development of odour, taste, and poor colour, together with reduced rewinding speeds owing to the greater cooling required.

2. *Carton Waxing*

Butter and cheese cartons, milk-bottle caps, and many similar semi-rigid paper-board articles are usually die-cut to shape before waxing. This permits a saving in wax, since only the useful portions are coated. The waxing involves an immersion in wax, usually accomplished on felt or canvas belts, which travel the length of a long tank of wax. The paper-board blanks are fed on to the belt at one end, and at the other end pass to squeeze rolls which polish their surfaces. In some plants the waxed blanks drop into cold-water tanks also equipped with conveyor belts. This treatment is claimed to improve the gloss.

The blanks are then formed into cartons with the wax usually acting as the sealing medium, although in some cases special adhesives are used. Cartons made in this way do not hold water.

In the manufacture of certain drinking-cups, paper blanks are waxed on a machine similar to that described above, and are then formed with dies. These dies are invariably water-cooled, and impart gloss to the finished article. The printed outer lamination can be fed through the waxer together with the plain under-wrap. The coating of wax seals the two together when they are passed through the squeeze-rolls.

When a strong, rigid carton or cup highly resistant to moisture and moisture vapour is required, it is normal practice to immerse the preformed article in molten wax. Such packages as milk cartons, ice-cream containers, and rigid waxed boxes utilize such methods, which are further described under the section on milk-carton manufacture.

3. *Milk-carton Waxing*

The U.S.A. are far in advance of the rest of the world in the field of waxed-paper-board milk cartons. About 10 per cent of the 10,000 million gallons of milk consumed per annum is sold in waxed cartons, and this application accounts for a very considerable proportion of the consumption

of refined paraffin wax in that country. Waxed milk cartons are so popular and are increasing in use so rapidly in the U.S.A. that one can only assume that it is mainly on economic grounds, and particularly due to post-war conditions, that they are not more widely adopted in Europe. In the U.S.A. two companies dominate the milk-carton industry, and it is very interesting to note that they have adopted two entirely different methods of manufacture. One manufactures the complete waxed carton in central factories, and transports them to dairies, the other major manufacturer distributes carton-constructing and waxing machines together with a supply of unwaxed flat paper-board blanks which are fed to the

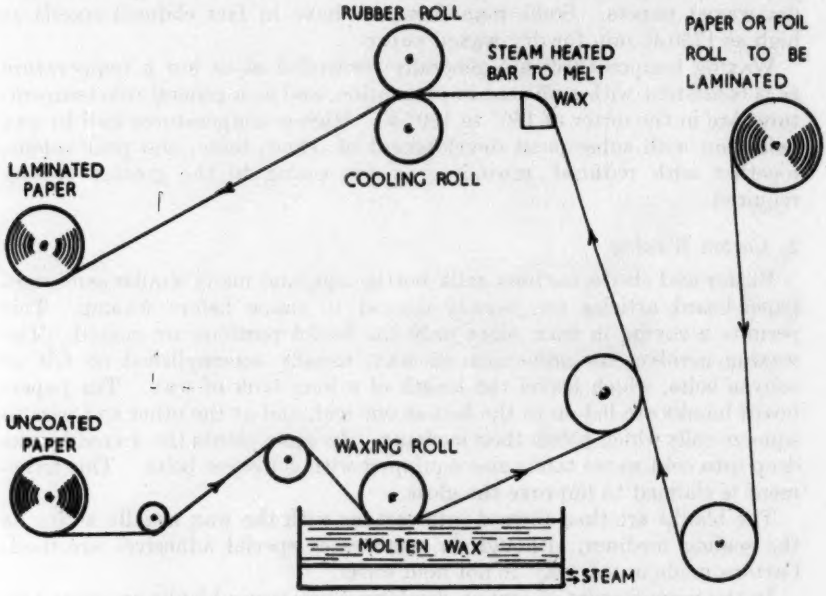

FIG. 5
LAMINATING MACHINE

machine. The machine folds, glues, and waxes the carton and then fills it with milk.

In the United Kingdom, similar methods of milk-carton manufacture have been in existence for many years, but as indicated earlier they do not seem to have enjoyed the success of their American counterparts. The author feels that it is only a matter of time before this type of milk package becomes widely accepted in the United Kingdom.

The type of operation described above in the manufacture of milk cartons can be, and is, widely applied to the waxing of many types of prefabricated cartons, cups, and other containers.

The important difference between this type of carton and those previously described as butter or cheese cartons, etc., is the fact that the latter type are waxed before forming, whilst the milk-carton type are waxed after forming. This leads to greater waterproofness and rigidity, particularly

at the base of the carton, which gets a relatively heavy coating due to wax drainage from the walls.

4. *Laminating*

Laminating is one of the most rapidly expanding fields of wax-paper packaging. Paper can be laminated to paper, paper-board, or to various viscose or metal foils by petroleum waxes, particularly by the plastic, flexible, and adhesive microcrystalline waxes. A typical laminating process is represented diagrammatically in Fig. 5.

The selection of the correct wax for laminating depends upon the materials to be laminated. For instance, it is comparatively easy to laminate paper to paper, because the wax will penetrate the paper, and the strength of the laminate is largely dependent upon the strength of the wax, which is almost certain to be adequate for most normal requirements.

If, however, it is wished to laminate paper and metal foil, it must be appreciated that there is no wax penetration of the foil, and the strength of the laminate depends mainly upon the adhesion of the wax to the foil. When it is required to laminate metal foil to metal foil or to viscose film, then the adhesive properties of the wax become of outstanding importance.

5. *During Paper Manufacture*

Wax can be incorporated in the pulp during the beater stage in the manufacture of paper. In this case it can be regarded as a sizing, and is incorporated in the form of an aqueous emulsion. This usage of wax in paper is not of major importance, and is not considered in this paper.

These methods of waxing paper and paper-board cover the vast majority of applications. There are methods of waxing complete packages by immersion in molten wax, and although not specifically dealt with in this paper, the requirements of such processes are dependent upon the precise type of package, and the factors involved can, in the main, be assessed from the information given on other types of waxing.

Those wax properties which are accepted as indicative of the suitability of wax for use in packaging should now be considered.

Practically all paraffin wax is bought or sold on a few very simple quality specifications. In general, the wax user requires his wax to conform to a specified melting point, and to be colourless, odourless, and tasteless. Now although on paper he buys to these requirements, he expects more, and in fact, he often carries out his own testing for some particular property. Sometimes he will specify this property and his method of testing, more often he is reluctant to do so. The author has therefore summarized those properties and methods of testing which, in his experience, have been most widely accepted as relevant to wax quality.

In Table V an attempt has been made to give an indication of the wax properties which are of practical significance to the major paper-packaging materials. Such properties as, for instance, boiling range are most important in wax production, but are not of practical significance in wax usage.

It is proposed to indicate the present position regarding the assessment of those properties to which has been given a rating of " very important," " important," or " significant."

Certain properties are not listed, because their importance is probably related to one or more of the properties recorded. For example, the adhesive properties of wax are important, but should be considered under the general property of sealing and bonding strength.

TABLE V

	Coated papers	Dry waxed papers	Laminated papers and foil	Coated paperboard	Impregnated paperboard	Laminated board	Milk cartons, etc.
Specific gravity	•	•	•	•	•	•	•
Neutralization and saponification value	•	•	•	•	•	•	•
Boiling range	•	•	•	•	•	•	•
Refractive index	•	•	•	•	•	•	•
Molecular weight	•	•	•	•	•	•	•
Flash point	••	••	••	••	••	••	••
Oil content	•••	•••	•••	•••	•••	•••	•••
Viscosity	••••	••••	••••	••••	••••	••••	••••
Melting point	••••	••••	••••	••••	••••	••••	••••
Colour	••••	••••	?	••••	••••	?	••••
Colour stability	••••	••••	?	••••	••••	?	••••
Odour and taste	•••••	•••••	•••••	•••••	•••••	•••••	•••••
Blocking tendency	•••••	••••	—	•••••	••••	—	?
Sealing or bond strength	•••••	?	•••••	?	?	•••••	—
Tensile-strength and modulus of rupture	?	?	?	?	?	?	•••••
Hardness	••••	•••	0	••••	•••	0	•••••
Flexibility	••••	••••	•••••	••••	••••	•••••	•••••
Gloss	•••••	—	—	•••••	—	—	•••
Grease and oil resistance	••••	••••	••••	••••	••••	••••	••••
Moisture-vapour resistance	•••••	••••	•••••	•••••	••••	•••••	—
Waterproofness	•••••	••••	•••••	•••••	••••	•••••	•••••

The key to the table is as follows:—

0 = Undesirable.
• = Of little practical significance.
•• = Of some significance.
••• = Significant.
•••• = Important.
••••• = Very important.
— = Not applicable.
? = Value interesting but debatable.

MOISTURE-VAPOUR PERMEABILITY

In the great majority of cases where wax is used in packaging its main function is to restrict the passage of water vapour to or from the contents of the package. Indeed, in a very large number of applications this relative impermeability of the wax film is the only property that really matters. With this fact in mind it is surprising how little is known about the moisture-vapour permeabilities of the various types of wax; a great deal of work has been done on waxed paper and board, but practically nothing on the waxes themselves. However, except for one or two special applications such as the waxing of fruit or cheeses, wax is never used alone but always supported by paper or board; so perhaps it is not unreasonable that it should be tested in the form in which it will ultimately be used. Unfortunately such results tend to be confused by the effect of the support (*i.e.*, the paper or board) and by the different conditions of application required by the various waxes. For example, it would be quite unrealistic to compare the moisture-vapour permeability (M.V.P.) of, say, 140/5 paraffin and a plastic 140/5 microcrystalline wax by coating them on to paper under identical conditions and then comparing the M.V.P.s of the two papers; a much fairer comparison would be obtained by first ascertaining the optimum conditions of coating for each wax and then comparing

papers so coated. Under such conditions there seems to be little to choose between *uncreased* specimens of paper coated with different types of petroleum wax; the permeability being in all cases extremely low, provided, of course, that the coating of wax is sufficient to form a continuous film. Results obtained on uncreased specimens, however, are insufficient, since the paper will almost certainly become creased in use, resulting in a certain amount of rupturing of the wax film and a consequent increase in permeability. This increase in M.V.P. will, of course, depend to a very large extent on the flexibility of the wax; the more flexible the wax the less liable it is to rupture when bent. Unfortunately, however, the most flexible waxes are, generally speaking, soft tacky ones, which are quite unsuitable for most coating purposes on account of their poor blocking characteristics, their lack of gloss, and their tendency to collect dust and dirt. It is necessary, therefore, either to arrive at a compromise between M.V.P. and these other qualities or, if this is not good enough, to find some method of plasticizing a wax without, at the same time, making it soft and tacky.

Table VI shows the M.V.P. of papers coated with paraffin wax and with a

TABLE VI

Wax	Melting point, °F	Moisture-vapour permeability, g/sq. m/24 hours, 50% humidity 73° F	
		Unfilled sulphite-paper, 20 lb/ream, 25% wax	
		Uncreased	Creased
Nil	—	406·0	—
Refined paraffin wax	130	0·20 0·45	12·4 16·2
Refined paraffin wax	140	0·26 0·51	18·6 12·3
Plastic microcrystalline wax	151	0·27 0·39	3·9 4·8

flexible, plastic microcrystalline wax as assessed by the standard TAPPI * method. These figures are selections of a great number of tests, and although typical should not be interpreted too rigidly. They are presented to illustrate the magnitude of the figures in which we are concerned and to emphasize :—

(1) the apparent similarity of the M.V.P. of paraffin and microcrystalline waxes when in a continuous film;

(2) the great importance of flexibility and plasticity in maintaining the M.V.P. of paper which may be creased.

It will be observed that from the point of view of M.V.P. after creasing, the plastic microcrystalline wax is much the best of the waxes, but such a wax is so tacky that it could not be used commercially as a coating wax.

* Technical Association of The Pulp and Paper Institute (U.S.A.).

Its application would be confined to laminating or possibly to blending with paraffin wax to modify the properties of the latter.

Waterproofness (and Wet Strength)

In several applications waxed paper and particularly waxed board are required to resist penetration by liquid water or aqueous solutions. Familiar examples of this are frozen-food packs, milk cartons, and waxed drinking-cups. As with M.V.P., very little work appears to have been done on the waterproofness of unsupported wax films—the tests are nearly always made on coated paper or board, and the waterproofness of a waxed board is even more dependent on the quality of the board than is its M.V.P. For example, if the board has a fluffy surface like blotting-paper, not only will it tend to soak up the wax during the coating process, but the fluffy fibres will also penetrate the thin film of wax and will act as wicks along which moisture can pass with relative ease.

Assessment of the waterproofness of packages usually takes the form of a simulated service test; that is to say the package is filled with the liquid it is intended to contain and then either stored under standard conditions or subjected to some form of endurance test representing the handling, etc., which the package will receive in actual use. A good example of this procedure is afforded by the tests conducted in the U.S.A. on milk cartons. In one of these tests, known as the " Absorption Test," a number of coated cartons are weighed and filled with 1 per cent lactic acid dyed with methylene blue. (Dilute lactic acid has been found to soften the wax and to penetrate the coating more readily than water.) The cartons are then stored for 72 hours, some at 45° F and others at 70° F. At the end of this period the number of cartons leaking is noted and the " bulge " of each carton measured. The cartons are then drained and re-weighed to determine the amount of liquid absorbed. The inside appearance of each carton is noted, absorption being apparent because of the blue dye; even " good " cartons show some absorption along the creases and seams, but " poor " ones show widespread absorption. For the " Endurance Test " twenty-four cartons are filled with water containing methylene blue, sealed, and placed in a delivery case. The case is then placed in an endurance tester held at 40° F, which drops the case vertically approx $\frac{3}{8}$ inch, 144 times per minute. The cartons are examined at least once an hour, and the test is continued until over 50 per cent develop leaks.

Generally speaking, the lower-melting-point microcrystalline waxes are more resistant to penetration by water than are the paraffin waxes, probably on account of their closer structure and greater flexibility. Blends of paraffin and microcrystalline waxes are widely used in the U.S.A. for coating milk cartons as also are blends containing polybutene; the addition of polybutene to the wax is claimed not only to improve its mechanical strength but also to reduce penetration by both water and fat.

Sealing or Bonding Strength

This is a most important property for self-sealing packages, but although the quality of the wax is of some significance, it is probable that methods and conditions of sealing much outweigh the effect of the wax quality.

The nature and weight of the paper, its moisture content, and the amount and nature of printing on it all have significant effects.

As is indicated under the section dealing with tensile strength this latter property has been claimed to be the wax quality having the greatest affect on sealing strength. This is possibly true but there is no known authoritative correlation between the two properties, although MacLaren * has recently given some very interesting data on the subject. So far as laminates are concerned, particularly non-porous foils such as viscose and metal, the more obscure properties of adhesion and cohesion are more important than tensile strength.

The methods adopted to evaluate sealing and bonding strength are in general quite logical. A section of two strips of waxed paper are heat-sealed, and the unsealed ends are gripped in clamps, one of which is fixed, and one movable on the application of controlled force. The force necessary to pull the sealed papers apart is recorded. This simple and logical procedure is, however, hopelessly confused by the number of variables which affect the result, and none of which have been standardized by the industry as a whole.

Some of the major variables are :—

(1) Angle of separation.
(3) Temperature.
(3) Humidity.
(4) Rate of application of force.
(5) Time between sealing and testing.

The importance of satisfactory sealing to packaging cannot be over-emphasized, so it is surprising that there is no universal standard for this property.

Incidentally, the author noted in America a tendency for two groups of thought on the economics of package sealing.

One group suggested that provided there was ample wax on a paper and that the sealing machine was functioning correctly, good sealing and economic packaging could be assured.

The other group felt that it was just as satisfactory and more economic to use less highly waxed, and hence cheaper, paper, and to rely on such devices as " end seals " to ensure good package seals. These end seals are usually paper, viscose or metal foil, or foil heavily coated on one side with a plastic microcrystalline wax or a blend of such wax and hydrocarbon polymers.

Tensile Strength

Tensile strength has appealed to many wax users in the belief that the test can be correlated with sealing or bonding strength of heat-sealed waxed packages. The commonly used methods are adaptations of the Tinius–Olsen or the Perkins paper-tensile-strength testing machines. The principle adopted is to measure the force required to rupture, by pulling apart, a specially moulded block of wax. The most common type of mould is illustrated in Fig. 6; the neck of the wax mould is normally 0·5 × 0·5 inch, giving a cross-section of 0·25 sq. in., but the results are multiplied by four to give a figure in pounds per square inch.

* MacLaren, F. H. *Industr. Engng Chem.*, 1950, **42**, 2134–41.

Although such tests are obviously of some value in determining a physical property of the wax, it is becoming increasingly evident that many wax users have decided that the test really only demonstrates experimentally a fact they already recognize—that the tensile strength of waxes varies. Until MacLaren * recently claimed correlation between his breaking or rupture-strength test and the sealing strength and blocking tendency of wax-coated paper, there has been very little, if any, real evidence that the test can be correlated with the sealing strength of the wax. It is probably true to say that most refined paraffin waxes will show tensile strength within the range 150–350 p.s.i. at 20° C, and it is equally true to say that waxes of such tensile strengths have been used with satisfaction by many waxed-paper manufacturers concerned with the sealing strength of their paper.

Before any general conclusion can be drawn regarding the possibility of correlation between tensile strength and sealing strength, a great deal more

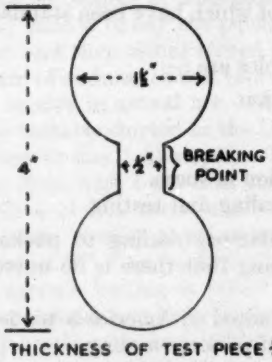

FIG. 6

DIMENSIONS OF WAX TEST PIECE FOR TENSILE STRENGTH MEASUREMENTS

must be done to standardize the many variables that can affect the results. Among the most important variables in procedure are :—

(1) The type of apparatus. Although many people use the Tinius–Olsen or the Perkins tensile testing machine, the author has seen several other types in use. One machine should be standardized.

(2) The dimensions of the wax test piece.

(3) The preparation of the wax test piece, particularly the rate of cooling in the mould and the application—or not—of vacuum during cooling. Also the humidity conditions during cooling.

(4) The period between preparation of the wax piece and its testing.

(5) The atmospheric condition of temperature and humidity during the test.

(6) The rate of applying the breaking load to the wax test piece.

Whilst it is suggested that tensile strength can be over-rated as a method of evaluating the sealing strength of waxes, it is probably of definite interest

* MacLaren, F. H. *Industr. Engng Chem.*, 1950, **42**, 2134–41.

to the manufacturer of waxed cartons, milk containers, etc., where the property can be more closely related to the actual strength of the finished carton, particularly the base of the carton that depends on a heavy coat of wax to give added strength.

It is probable that the technologist of the wax producer obtains more benefit from the test than does the wax user. Although, as has been indicated, there is little correlation between sealing and tensile strength, and a wide range of the latter have been found suitable for most wax users, nevertheless there obviously can be waxes of unduly low tensile strength; and the wax technologist and the oil industry have utilized the test to determine the effect of variables in his type of wax, and in the wax-producing process.

For instance, oil content has been shown to have a very marked effect upon the tensile strength of some waxes. Wax B in Fig. 7 gives an example

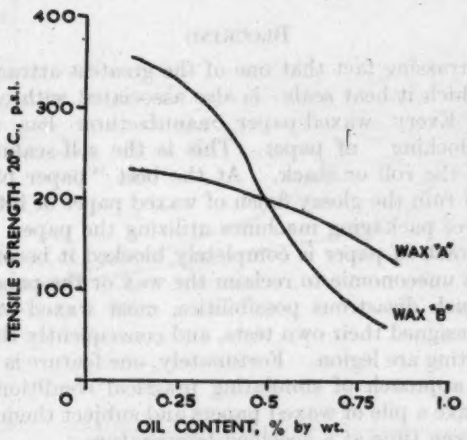

FIG. 7

EFFECT OF OIL CONTENT ON TENSILE STRENGTH OF PARAFFIN WAX

to the effect to be expected with a narrow-cut refined paraffin. But in the case of Wax A, which is a refined wax of wider cut, the effect of oil is not so marked.

This relation between oil content and tensile strength has been used by wax producers and wax users as a check on oil content of wax from known sources, but most of the wax users concerned have ceased to utilize this check, since the new rapid solvent methods for oil in wax have been available. These methods are referred to later.

Various other factors are known to affect the tensile strength of wax from a given source. For instance, it has been found that increasing the width of cut of a wax can increase the tensile strength. It should be realized that all commercial waxes consist of a mixture of waxes of various melting points, and according to the crude, and method of production, some waxes contain a more narrow range of melting points than do others; and it can be shown that the narrow-cut waxes from a given source may be of lower tensile strength than the wider cut. This is often true of waxes

with melting points above 135° F which are frequently narrow-cut waxes. Such waxes can have their tensile strength improved by the addition of the lower-melting-point and more plastic paraffin waxes. Tensile strength can also be improved by the addition of a small proportion of certain microcrystalline waxes, and the addition of various polymers.

" Modulus-of-rupture " tests are considered by some wax users, particularly carton manufacturers, to be a more logical means of evaluating wax strength than tensile tests. Modulus of rupture tests usually take the form of applying a load to a strip of wax supported at each end. Increasing force is applied to the centre of the unsupported section until " rupture " occurs. The test would seem to offer a more practical approach to the objective of such tests than does the tensile measurement, and has the advantage of requiring less elaborate apparatus, but the variables that affect tensile-strength measurement are equally applicable to modulus-of-rupture tests.

Blocking

It is an embarrassing fact that one of the greatest attractions of wax—the ease with which it heat seals—is also associated with one of its major disadvantages. Every waxed-paper manufacturer has at some time experienced " blocking " of paper. This is the self-sealing of sheets of waxed paper in the roll or stack. At the best " paper blocking," when only partial, will ruin the glossy finish of waxed paper or interfere with the smooth running of packaging machines utilizing the paper. At the worst, when a roll or stack of paper is completely blocked it becomes practically worthless. It is uneconomic to reclaim the wax or the paper.

Faced with such disastrous possibilities, most waxed-wrapping manufacturers have designed their own tests, and consequently the methods and conditions of testing are legion. Fortunately, one feature is common to all, *i.e.*, the logical approach of simulating practical conditions. Almost all manufacturers take a pile of waxed papers and subject them to a prescribed pressure for a given time at a specified temperature.

A typical test stacks several sheets of paper on a flat surface and applies a flat weight to them. The weight may be in the order of 0·5 to 1·0 p.s.i., which figures can be related to practical conditions. The weighted stacks are maintained at a prescribed temperature, which varies according to requirement from 70° to 140° F, and for 4 to 24 hours, and inspected for signs of blocking.

TAPPI have made an effort to standardize a method, but it is not known how far this has been adopted by the industry.

Apart from such efforts to make a practical assessment of the problem, much consideration has been given to the development of a test for the wax itself which might correlate with the blocking tendency of waxed wrappings.

In the author's opinion one of the most hopeful approaches is the determination of the temperature/penetration (hardness) relationship of the wax. Fig. 8 illustrates the difference that can occur between two waxes of equal melting points and of equal hardness at 25° C. The example given relates to microcrystalline wax, because in this case a standard method of wax hardness can be applied. Unfortunately with paraffin waxes no such

standard method is applicable, but some of the methods as described in the section dealing with hardness can be utilized to give similar curves with paraffin wax.

It will be seen from Fig. 8 that there is a definite break in the curve at 40° C for wax A, indicating a marked softening, but wax B does not show a similar effect until 48° C. It is reasonable to assume that wax A is more likely to give a lower temperature of blocking than will wax B. But here again no authoritative correlation exists so far as the author is aware. The explanation of such difference between two waxes of similar melting point and initial hardness is to be found in :—

(1) *Oil Content.* A high oil content will generally give a lower softening point.

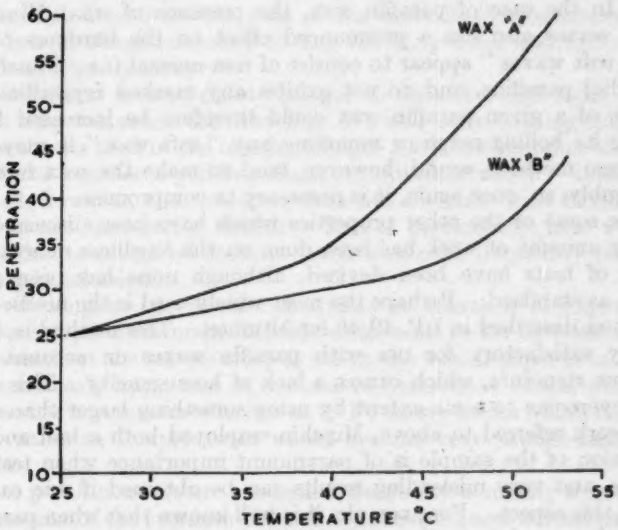

FIG. 8

TEMPERATURE–PENETRATION CURVE

(2) *Width of Cut.* A wax containing a high proportion of wax melting at a temperature below that recorded for the melting point of the mixture will show a lower softening point than will a more narrow-cut wax.

(3) *Transition Point.* Wax crystals vary in their physical structure on change of temperature, and it is probable that this characteristic will have a bearing on the apparent softening point of a wax.

Various other tests have been applied to wax in an endeavour to assess blocking tendency, and perhaps one of the most interesting is the Abraham Consistometer, which was developed for the testing of bitumen and later applied to rubber. This test has been used to determine temperature/consistency curves for waxes, and has shown results which can be related to the temperature/penetration curves referred to earlier.

Hardness

As has been mentioned already, the " blocking tendency " of wax-coated paper depends to a large extent on the hardness of the wax (particularly at elevated temperatures) : a hard wax is also desirable because it gives a high-gloss paper which is less susceptible to " scuffing " or surface damage and less liable to collect dirt and dust than one coated with softer wax.

Generally speaking, the hardness of a wax depends very largely on its melting point and its oil content; the higher the melting point and the lower the oil content the harder is the wax. Minchin * illustrated these effects in the paper on petroleum waxes which he presented to the Institute three years ago. But melting point and oil content are not the only factors determining hardness. The width of cut is also of importance, a narrow-cut wax being considerably harder than a wide-cut wax of the same melting point. In the case of paraffin wax, the presence of what Minchin calls " soft " waxes also has a pronounced effect on the hardness of a wax. These " soft waxes " appear to consist of non-normal (*i.e.*, branched-chain and cyclic) paraffins, and do not exhibit any marked crystallinity. The hardness of a given paraffin wax could therefore be increased by either reducing its boiling-range or removing any " soft wax " it may contain. Both these methods would, however, tend to make the wax more brittle and crumbly, so, once again, it is necessary to compromise.

Unlike some of the other properties which have been discussed, a considerable amount of work has been done on the hardness of waxes and a number of tests have been devised, although none has been generally adopted as standard. Perhaps the most widely used is the needle-penetration test as described in I.P. 49/46 for bitumen. This method is, however, not very satisfactory for use with paraffin waxes on account of their crystalline structure, which causes a lack of homogeneity. This difficulty can be overcome to some extent by using something larger than a needle. In the work referred to above, Minchin employed both a ball and a cone. Preparation of the sample is of paramount importance when testing wax hardness, and very misleading results can be obtained if due care is not given to this aspect. For example, it is well known that when paraffin wax is allowed to cool from its setting point to room temperature it usually changes its crystal form at a temperature known as the transition point; the extent of this change in crystal form will depend to some degree on the rate of cooling—if the cooling is very slow the transition will be more complete than if the samples were shock-chilled from a temperature above its transition point.

Furthermore, Minchin has shown that shock-chilling (or " quenching " as he calls it) from a temperature just below the transition point gives an appreciably harder wax than is obtained by natural cooling or by quenching from higher temperatures. In view of the common practice of shock-chilling waxed paper in water or on cold rollers, these findings may be of considerable practical significance. It should be mentioned, however, that the effect of quenching is not permanent—the wax slowly reverts to the state it would have attained if allowed to cool normally.

Various additives have been proposed to increase the hardness and

* Minchin, S. T. *J. Inst. Petrol.*, 1948, **34**, 558.

" scuff-resistance " of paraffin wax, small proportions of the higher-melting-point microcrystalline waxes (the so-called petroleum ceresines) are quite effective, but the additive most widely used for this purpose is undoubtedly polyethylene.

Flexibility

As has been already shown, the moisture-vapour permeability of uncreased waxed paper or board is extremely low; it is only when the wax film is ruptured by creasing that the permeability becomes really significant. The degree of rupturing depends very largely on the flexibility of the wax at the temperature of creasing. Most wax-refiners have a method which they use for checking this characteristic, but, once again, there seems to be no generally accepted standard test. The usual technique is to take a thin strip of the wax and bend it under specified conditions of temperature and loading until it breaks (in the case of the more flexible microcrystalline waxes it is sometimes necessary to flex the strip back and forth several times before failure occurs).

Flexibility is, of course, closely related to ductility, and some workers claim that they can assess the flexibility of a wax by measuring the elongation of specimens used in the tensile-strength test; the modulus-of-rupture test should be capable of yielding similar useful information. It should be emphasized, however, that hardness does not correlate with flexibility; a soft wax is not necessarily flexible. This is particularly true when the softness is due to a high oil content; such waxes are frequently putty-like and lacking in cohesion.

When referring to the relative flexibility of waxes it is important to specify the temperature under consideration and, so far as possible, tests should be made at the temperature at which the waxed-paper is to be used. This is particularly important in the case of frozen-food wraps, which may be subjected to temperatures as low as 0° F; many waxes which have good flexibility at room temperatures would become very brittle under these conditions.

So far as paraffin waxes are concerned, flexibility is mainly a function of width of cut and of the presence of " soft " waxes (*i.e.*, non-normal paraffins). As might be expected wide-cut waxes are the most flexible, while the " soft " waxes appear to act as plasticizers. In the case of microcrystalline waxes the possible presence of appreciable amounts of aromatic or naphthenic hydrocarbons may also contribute towards increased flexibility. The addition of small proportions of microcrystalline waxes to paraffin waxes effects a considerable improvement in flexibility, and several other materials, notably polymers such as polyethylene and polybutylene, are used for the same purpose.

Grease and Oil Resistance

The man in the street usually classes waxed papers under the general heading of " greaseproof-paper " and, although this term is more correctly applied to vegetable parchments, there is a good deal to be said for his point of view, because in many applications waxed paper is called upon to withstand the action of oils and greases. Notable examples are in the packaging of greasy foodstuffs, particularly butter, and in the wrapping of metal parts coated with temporary corrosion preventives.

Probably the most widely accepted method for assessing the grease and oil resistance of waxed paper is the TAPPI Standard Method T454m–44. It has been demonstrated that some oils penetrate waxed paper much more readily than others, and that some waxes are much more oil-resistant than others and, in particular, that microcrystalline waxes are much better in this respect than are paraffin waxes.

Odour and Taste

These very important properties of wax defy standardization. They are so much a matter of personal opinion that it is unlikely that a really reliable standard test will ever be devised.

So far as odour contamination is concerned we can look to three major possibilities :—

(1) *Odour Due to Poor Refining*

This is the odour generally described as "oily" or "kerosine" which can be, and is, removed by a good refiner of paraffin wax. It can also be removed from microcrystalline waxes, but in this case the process is more difficult and costly, and hence microcrystalline wax free from taste and odour becomes very expensive.

(2) *Odour Developed during Shipment and Storage of Wax*

Odours in this group can be developed in many ways. The most common is a jute odour picked up from the bags in which slabbed wax is usually shipped. Cotton or paper liners in the jute bags have helped to reduce such odour.

Another very common source of odour contamination is due to the all-too-common practice of storing slabbed wax in poorly ventilated buildings which contain other products of strong odour. As an example, wax slabs stored in the proximity of cheese or soap will develop a distinct odour of such products.

In America much molten wax is shipped in bulk. If the wax is of good odour on leaving the refinery, and is transported in clean tank vehicles and not unduly heated during transit or discharge, it will not develop objectionable odour.

(3) *Odours Developed during Use*

Wax that has been over-heated acquires an odour often described as of coconut. Most wax users are aware of the danger of overheating wax, and endeavour to keep their wax temperatures below 180° F, but thermostatic controls are not infallible, and their failure can lead to over-heating, with disastrous effect on wax odour. Odour and taste of wax are frequently contaminated in use by printing inks, poor-quality paper, and by lubricating oils from the waxing machines.

Methods of testing odour vary, but the most common is to place wax shavings in a chemically clean glass-stoppered bottle for 24 hours and then test the odour. Another test melts the wax in a glass bottle to the temperature at which it will be used in practice. The wax is maintained at the

temperature in the stoppered bottle for some hours and then tested for odour. A further test melts a quantity of the wax in boiling water. The steam is claimed to bring out the odour very rapidly.

However, in all these tests the odour is finally assessed by an individual who bases his assessment upon his previous experiences. Hence most people concerned with wax odour have certain selected persons detailed for the test, with subsequent confusion when new people are introduced.

Taste is almost invariably tested by a particular experienced person chewing a portion of the wax. As in the case of odour the great weakness of this test is its dependence upon the experience of the person carrying out the test.

Colour

The colour of paraffin wax is of importance, and fortunately methods for determining the property are fairly well recognized. The recognized methods all measure the colour in the liquid state. The Institute of Petroleum method I.P. 17/45 recommends the use of the Lovibond Tintometer, in which the colour of filtered molten wax in depths of 2 inches, 6 inches, or 18 inches, according to the intensity of the colour, is compared with standard colour glasses.

In America the Saybolt Chromometer method for refined oil is more widely used. This test is fully described by the ASTM D156–49 and by the Institute of Petroleum in I.P. 18/42. Essentially the test determines the depth of molten wax which gives a colour intensity equivalent to standard glasses.

Microcrystalline waxes are in general of darker colour than paraffin wax, and methods such as above, which were originally designed to measure varying degrees of water-white products, became impracticable as they use considerable depth of molten wax. However, the Lovibond apparatus can be applied by the use of glass cells which give very little depth of molten wax, for instance, cells giving films of wax as thin as $\frac{1}{16}$ inch can be used.

In America the Tag Robinson apparatus has been used for microcrystalline wax. This method adopts a principle similar to the Saybolt method in so far as the depth of the molten wax can be varied to give a colour intensity equivalent to standard glasses.

From time to time demand arises for a method to determine the colour of solid microcrystalline waxes and petroleum jelly. The demand is logical, as most microcrystalline waxes are bought and sold on their colour in the solid state rather than in the liquid state. The major stumbling-block in producing a suitable method has been the divergence of opinion on whether the colour should be determined on a cut, moulded, or air-cooled wax surface.

Stability of Odour, Taste, and Colour

The stability of the odour, taste, and colour of wax has at one time or another been the concern of most waxed-paper or board manufacturers.

Wax stability is largely a function of the oxidation resistance of the wax. Very potent oxidation inhibitors are available and are widely used, but some manufacturers of food-packaging materials are reluctant to adopt

them in the fear that they will introduce toxicity hazards. Such an attitude is most commendable, but can sometimes be maintained unnecessarily. It is suggested that wax users should thoroughly investigate the possibilities of these inhibitors before they decide to dispense with them. Oxidation will cause a wax to discolour and to develop odour and taste. The oxidation of all petroleum products is accelerated by increase in temperature, oxygen availability, and by light, particularly sunlight. Furthermore, many metals, particularly copper, catalyse oxidation. With all these variables affecting the property, it is not surprising that there is no generally accepted method of testing wax stability.

In most tests known to the author the procedure has been to melt the wax in a glass vessel with or without a catalyst, and maintain it at temperatures ranging from 160° to 300° F for a certain time interval which may be 24 hours or 100 hours. After the heat treatment the wax is allowed to cool, and compared visually or for taste or odour with the original wax. The oil industry has considerable experience of accelerated oxidation tests for most of its products, and it has learned to treat such tests with very great caution. It is felt that any effort to standardize tests should be confined to those which simulate practical conditions as closely as possible. It is believed that two tests should be developed; one which assesses the stability of molten wax in the presence of air and steel and/or copper for a prescribed period; and a second test which assesses the stability of a solid film of wax in sunlight at a prescribed temperature. The stability of waxes on such testing should be assessed on their change in colour, because normal chemical tests to assess the degree of oxidation, such as the determination of neutralization value are insufficiently accurate for the purpose. Changes in taste and odour can be assessed by the methods recorded for such properties.

The tension at an oil/water interface has been successfully applied to detect incipient oxidation of oils used for turbine lubrication or electrical insulation. In such oils it is important to detect oil oxidation before the effect becomes apparent through failure of electrical insulation or acidity and sludge formation. It may be that such a test could be used to detect incipient oxidation in molten wax.

Gloss

Most wax-paper manufacturers at some time require to produce high-gloss products. Gloss is produced by rapid cooling after application of the wax to the paper, and typical methods have already been described. Shock cooling produces fine wax crystals which reflect light, while slow cooling results in larger crystals with a reduction in light reflection or gloss. Glossy wax coatings tend to dull with age, because of changing crystal structure and oxidation. Such deterioration is sometimes accelerated by residual heat in the waxed-paper roll, and this the manufacturer endeavours to avoid by increasing the cooling, or reducing the waxing speed.

Although the wax-paper manufacturer himself can do much to influence the quality of gloss on his paper, it is also necessary to have certain wax quality; the wax must be hard in order to resist scuffing, which spoils gloss, and to prevent the sticking of dust which is obviously detrimental. It is

probable that the two wax properties which have the greatest effect upon the gloss of paraffin wax are oil content and hardness.

The various attempts which have been made to assess gloss have usually been based on the photometric measurement of reflected light, but owing to the great difficulty in preparing reproducible samples, no completely satisfactory method has yet been found.

Oil Content

It is important to distinguish between paraffin and microcrystalline waxes when considering oil content. Thus micro-waxes are much more oil-retentive, so that whereas an oil content of, say, 2 per cent would be considered very high in a refined paraffin wax, it would be unusually low for a micro-wax.

So far as the paraffin waxes are concerned, most packaging requirements demand that the oil content should be as low as possible (a figure frequently quoted in this connexion is 0·5 per cent max). The presence of an excessive amount of oil gives rise to odour and taste as well as imparting an oily feel to the wax and reducing its tensile strength, hardness, and gloss. High-oil-content waxes also lead to staining, because the oil tends to migrate or bleed from the wax. There appears to be a certain amount of misunderstanding regarding oil-content, however. Many users seem to think that there is a clear-cut dividing line between on the one hand wax, and on the other oil; they find it difficult to understand why different methods of determination should yield quite widely divergent results. In actual fact, of course, there is no such dividing line. Thus, in the case of a 135/140 paraffin wax, for example, there may be 0·3 per cent of the hydrocarbons having melting points below 60° F, 0·5 per cent below 70° F, 1 per cent below 80° F, and 5 per cent below 100° F—any of these figures could be considered as the " oil-content " of the wax depending on the definition of " oil."

With the single exception of melting point, oil content is the only major property of wax to receive the attention it deserves. The old press methods of determination are now obsolete, and there is wide acceptance of the solvent-extraction method for paraffin wax recommended by the ASTM and designated ASTM D721–47. In the last year or two considerable attention has been given to modifying this method in order to give easier manipulation and simpler apparatus. The current tentative method D721–49T is, with certain modifications, likely to displace D721–47. Both these methods are based on the principle that if paraffin wax is dissolved in warm methyl ethyl ketone and then cooled to −25° F, all the wax is precipitated, leaving the oil in solution. A prescribed portion of the methyl ethyl ketone solution is drawn off through a filter, evaporated, and the residual oil weighed.

As both the ASTM and the Institute of Petroleum are currently studying the D721–49T with a view to adopting a slightly modified version, it is hoped that a method for paraffin wax acceptable to both the U.S.A. and the United Kingdom will shortly be standardized.

The oil content of microcrystalline wax still presents some difficulty, but here again it is hoped that a modification of the solvent employed will enable the ASTM 721–49T to be applied to the microcrystalline waxes.

Melting Point

The melting point of wax is of obvious importance. Not only does the wax producer have to adjust his manufacturing procedure to obtain and handle wax according to melting point, but the user must also adjust his waxing procedure. For instance, with a wax of high melting point he must have higher operating temperatures, which in turn necessitates more cooling of the finished paper or board, or he must adopt slower production speeds. The user of the finished waxed packaging is also concerned because the wax melting point will limit the temperature to which he can subject his package.

Melting point is, therefore, of such obvious importance that it is not surprising that it is by far the most commonly quoted characteristic. Refined paraffin waxes are bought and sold almost entirely on a melting-point basis.

The melting points of paraffin waxes are usually determined by a form of " cooling curve " method such as I.P. 55/44 or ASTM D87–42. This sort of method is not suitable for microcrystalline waxes which do not show definite " platform " on their cooling curves. The melting point of such waxes is best indicated by the congealing-point or rotating-bulb method I.P. 76/44 or by a " drop point " method such as ASTM D127–49. The cooling curve " platform " can give misleading results with blended waxes. Thus it is possible to blend a high-melting-point microcrystalline wax with paraffin wax to give an apparent setting point according to the I.P. method of say 160° F, whereas the wax is virtually fluid at around 140° F. The converse is also quite common, for example the addition of 1 per cent of some polymers will not affect the I.P. setting point, but can increase the drop point ASTM D127–49 by several degrees.

It is apparent that wax melting point is important but that it should not be interpreted too rigidly in particular it should not be regarded as an indication of softening point. In this latter connexion reference should be made to Fig. 8.

Viscosity

Viscosity is of importance to the wax user because it very largely decides the amount of wax picked up by the waxing rollers and by the material being waxed. It will also affect the amount of penetration of the wax into the paper or board.

Paraffin waxes, as indicated in Table IV, do not vary significantly in viscosity, microcrystalline waxes do vary appreciably in this respect, but neither paraffin nor microcrystalline waxes give rise to problems on account of their viscosity. However, the increasing tendency to compound polymers in wax for various specific purposes has given rise to expected trouble due to the enormous increase in viscosity associated with their presence. Not only are viscous wax compounds more difficult to " squeeze " or " scrape " from coated paper or board, but at high speeds they tend to be flung around the waxing machines with subsequent loss of wax and of production. The effect on the viscosity of wax on addition of poly*iso*butylene is illustrated in Table VII.

TABLE VII

Molecular weight of polyisobutylene	Viscosity, cs at 210° F		
	% polymer in paraffin wax		
	Nil	1%	4%
13,000	3·6	4·8	10·0
45,000	3·6	7·5	42·6
70,000	3·6	11·7	158·0
100,000	3·6	15·0	731·0

The viscosity of wax and wax blends can be readily determined by the method for kinematic viscosity, standardized by the Institute of Petroleum and the ASTM under their designations I.P. 71/47 and ASTM D445–46T.

CONCLUSIONS

Twenty-one characteristics of petroleum wax have now been considered, six of these (specific gravity, neutralization and saponification value, boiling range, refractive index, molecular weight, and flash point) have been assessed as being of relatively small practical significance to the waxed-paper and carton industry, and have not been considered in detail.

The remaining fifteen characteristics have been rated in importance according to the author's personal opinion, which is based on his experience with the waxed-paper and carton industry. It is admitted that the assessment is debatable, but it is felt that this paper would be justified if only it ultimately produced a generally accepted rating for wax properties.

Having rated these fifteen characteristics, an attempt has been made to indicate current methods of evaluating the characteristics and current thoughts on correlating such characteristics with service performance.

It is to the credit of the producer of wax, the oil industry, that their activity has led to wide Anglo-American agreement on the methods of assessing oil content, viscosity, melting point, and colour, whilst the users of wax for packaging materials have general agreement on moisture-vapour-permeability testing. Odour and taste are so much a matter of personal opinion that agreement on methods to assess such characteristics is virtually impracticable.

This means that there remains a confused picture on nine important characteristics which should be studied by the wax users in co-operation with the wax producers in an endeavour to establish agreed methods of evaluation.

The nine characteristics are :—

(1) Hardness.
(2) Flexibility.
(3) Strength—such as tensile or rupture.
(4) Sealing or bonding strength.
(5) Blocking tendency.
(6) Gloss.
(7) Colour, odour, and taste stability.
(8) Waterproofness.
(9) Grease and oil resistance.

It is suggested that as far as the United Kingdom is concerned the oil industry should give a lead in establishing a standard method to assess hardness, flexibility, strength, and stability of waxes, whilst the manufacturers of packaging materials should assume responsibility for the standardization of methods for assessing sealing strength, blocking tendency, gloss, waterproofness, and grease and oil resistance. In such developments the U.K. could with advantage simulate the activities of the joint TAPPI/ASTM Committee on Petroleum Waxes which is initiating in the U.S.A. the co-operation that could be developed with advantage in the U.K. Furthermore, the U.K. industries concerned should co-ordinate their views as far as possible with those of their counterparts in the U.S.A.

Although it is suggested that the technologists of the two industries concerned should make themselves responsible for clarifying the position regarding certain characteristics, it is most important that both industries should closely co-operate throughout their deliberations. Furthermore, it is equally important that they take account of the affect their findings might have on the economics of their industries.

It is perhaps worth emphasizing at this point the interdependence, or even mutual exclusiveness, of many of the desired properties of petroleum wax. Thus, a demand for an improvement in some particular property can, very often, be satisfied only at the expense of some equally important characteristic. It is also in place to record two warnings at this stage. The first relates to specifications. In such studies of characteristics as we have recommended there is a danger that restrictive national or international specifications will result. Such specifications can be a menace because :—

(1) They set minimum standards of quality which have an unfortunate habit of becoming maximum standards of quality and hence retard quality development;

(2) without regard for the economics involved they can set standards which entail increased cost of the products concerned.

It is not the author's wish to attack specifications. These are, of course, quite necessary, but it is intended to stress the dangers of developing specifications which are restrictive so far as quality development is concerned and/or conducive to increased cost.

It should be appreciated that a basic overall characteristic of paraffin wax is the fact that the same quality is well suited to the many diverse uses referred to earlier. This leads to economy in wax production and consequently to lower prices than would otherwise prevail. It is in the interest of both the wax producer and the user to preserve the universality of use as far as possible. In the U.S.A. packaging requirements are becoming more and more specialized, and this tends to lead to special grades of wax with all the attendant difficulties of processing, segregation, and inventory. When this occurs price increase follows, and thereby defeats one great advantage of wax for packaging.

Let us conclude on the theme that our standard of living is largely dependent upon good cheap packaging, in which petroleum waxes have a vital part to play. Thus it is in the interests of all concerned that the wax

producers and the package manufacturers should co-operate with mutual trust and understanding of each others problems.

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Discussion

The President: The objects of the Institute of Petroleum include that of providing a forum for the discussion of any problems of interest to members of the industry. I know nothing, myself, of the waxes problems, except as affecting production problems; I recall that a long time ago I regarded wax as an irritating material which retarded the flow in oil wells and required special measures to be taken to deal with the problems created by it.

When one visits America and boards an aeroplane, there for the first time one is very much impressed by a perfect meal served in small wax containers. From the discussion of this paper, whilst one is similarly impressed by the extent of the use of such containers throughout the milk industry in Britain, one is struck by the great use of this form of container in America in comparison with Britain. Mr Thorpe has introduced a subject of considerable importance to the waxed-paper industry and, of course, to the petroleum industry.

D. L. Samuel: We are perhaps apt to regard our products as such and not to give sufficient attention to their application. This paper focuses attention on a most important application of a petroleum product. In some respects it appears that perhaps this paper has been written more from the point of view of the paper industry than the petroleum industry; thus, as an example, the author refers to TAPPI methods. This may be familiar to people in the paper industry, but how many in the petroleum industry know anything about them? We might with advantage have heard more about some of these test methods. For instance, some of us would like to have heard more about the M.V.P. method (moisture, vapour, permeability), and of how this characteristic is measured. The same can be said about tests for resistance to grease. Perhaps some of these details will come out during the discussion.

The impression one gains, and one which I think the author wishes to convey, is that there is a complete lack of any useful standardized methods for measuring the properties of waxes for their application to the paper industry. The paper people themselves appear to have a number of methods, but few of them are standardized, and they apparently differ very

largely from group to group. The petroleum industry also has a number of tests for paraffin waxes, but few of them seem to have any significance to the paper industry. There is here opportunity for the two industries to get together and discuss tests and test methods, and perhaps as a result of joint consultations evolve some tests which really have some value.

I would like to know whether the addition of soaps to wax has ever been considered with a view to improving hardness, or would the presence of soaps be unsuitable for the purpose for which waxed papers are used ?

G. F. UNDERHAY : I am connected with the British Paper and Board Makers' Association, and I welcome the opportunity to say a word or two about the paper side in relation to the wax problem.

In the first place, I like the way in which Mr Thorpe has boldly suggested the types of tests which should and should not be applied. Particularly I like the statement that it is most important not to introduce unjustifiably restrictive specifications. We in the paper industry have been fighting hard to try to prevent that sort of thing happening, and trying to put right cases where it has happened. As the result of the suggested collaboration I hope we shall go forward from this meeting to face these wax problems squarely and ensure that we do not introduce restrictive tests.

The problems involved will be difficult to handle; and I feel that any material which melts in terms of degrees Fahrenheit and boils in terms of degrees Centigrade will indeed give rise to complications.

However, here is an opportunity to take up the suggestions thrown out by Mr Thorpe and to try to get the two industries together on this important subject. It happens that in the paper industry we have an organization which I think—and I speak as a private individual, although I have had some connexion with its committees in this matter—could very well work in with your organization in the petroleum industry. We have a Paper Makers' Association which has a number of technical committees, including a Paper Testing Committee with a number of sub-committees. Mr Thorpe and I have had an unofficial talk and feel that we should have a new sub-committee working under the main Paper Testing Committee to deal especially with the measurement of the properties we want to attain when we apply wax to paper. At least one member of that sub-committee should be a member of Mr Thorpe's Sub-Committee and in that way close liaison would be maintained between the two sub-committees, one working more particularly on the properties of the wax, and the other more particularly on the properties of the paper after the wax is applied and, also, on the way the wax behaves when it is applied.

We also thought in terms of having an exploratory meeting subsequent to this present meeting, which might be composed of members of your Wax Sub-Committee and our proposed Wax Paper Testing Sub-Committee, so that the allocation of work might be discussed. I have passed on those thoughts to the Executive Committee of the Paper Makers' Association, who have received them favourably.

We need to be careful to ensure that the tests we set up are the ones we want. I am not sure, for instance, although I am open to correction, that from the paper-making point of view we shall be interested in the M.V.P. of the wax as such. The things that matter are the characteristics of the

products when made, together with aspects of quality that are important during the actual process of manufacturing waxed papers. If the two sub-committees can sort out these problems in greater detail, the paper industry would certainly welcome it. I hope the meeting I have suggested will materialize.

MR THORPE: In reply to Mr Samuel, and in connexion with the wax treatment of paper I do not know of the use of soap to improve the hardness of the wax. But there are some wax users here who may be able to throw light on that subject. Other materials, of course, are used to harden wax.

I did rather emphasize paper and the paper industry, but I rather felt that no opportunity should be missed to make the petroleum industry ever more alive to its obligations to other industries, and to the paper industry in particular. The fact that I have not quoted details of the TAPPI methods arises from my concern that the paper should not be too long. The methods of the Association are readily available on request.

With regard to the remarks of Mr Underhay concerning degrees Centigrade and degrees Fahrenheit, he has spotlighted a weakness in the testing methods of our industry, which many of us regret.

I am glad that Mr Underhay feels as we do on this matter of co-operation between the Institute of Petroleum and the Paper Makers' Association. I think such co-operation will lead to better packaging, and the petroleum industry will do its utmost to advance such aims.

G. L. RIDDELL: I should like to associate myself with the remarks made by Mr Thorpe and Mr Underhay. I speak as the Director of Research of the Printing, Packaging, and Allied Trades Research Association, which perhaps in this instance stands half-way between the petroleum industry and the paper industry. I feel sure that nothing but good can come out of this proposal, and I do hope that after this meeting definite steps will be taken in that direction. I am certain there is need for these tests to be dealt with; I am also certain that in many fields quite a considerable amount of information already exists, and that some of the tests, therefore, could be developed very quickly.

If my organization can be of help, that help will readily be placed at the disposal of the Institute of Petroleum and the paper industry.

DR W. M. MAZEE: May I draw attention to the work of the TAPPI/ASTM Committee on Petroleum wax, which last year held a meeting at Rochester, New York? Several sub-committees were formed to deal with blocking, laminating, gloss, sealing, and so on. They have started work and are endeavouring to standardize methods of preparing samples of wax papers and methods of measurement. They have made a survey of the methods used by various people and have started to co-ordinate them. If the suggested combined committee is formed here it will be useful to find out what that other committee is doing, in order to avoid duplication of work.

In regard to the present paper, I think the oxidation stability of wax has to be taken seriously into consideration. It is an important factor, and the consumers in the United States are very anxious to have good oxidation stability. Most of them add inhibitors to prevent oxidation of waxes.

The next point is that of tensile strength, and so far no correlation could be found with practice. That is not very astonishing, because so far tests have been made with very thick samples which have to be cooled very slowly, whereas the wax lying on the paper is cooled very quickly. We have developed a method, however, for which we make very thin wax samples, layers only a few tenths of a millimetre thick, and those layers can be solidified within a second. Test-pieces are punched out by special equipment, and those test results might give better correlation with practice.

As regards penetration, many samples having the same penetration at certain temperatures have been tested, but they vary in other respects. In our opinion penetration is not a very good measure for a blocking test on waxed paper. In some cases it gives a very rough indication, but correlation is not to be expected while the compositions of the waxes have a great influence on the blocking tendency of the waxed paper.

I fully agree with the remarks made about water-vapour permeability, because the water-vapour permeability of the wax layer alone will be of no use to the paper industry, in that the transmission of water through the paper is effected by the fibres and not by the wax layer. The M.V.P. of the wax layer alone is very low.

No reference is made in the paper to scuffing of the waxed paper being important. Usually it is considered to be important, because in practice it is desired to prevent the wax coming off the paper, and secondly, to prevent some of the wax sticking to the rollers of the waxing machine and giving a bad appearance to the rest of the paper passing through the rollers. A quantitative test, which gives satisfactory results, has been developed.

A. WEBB: A lot has been said about the various properties of wax in regard to its application to paper, but one particular property which has not been dealt with very much is one which concerns the packaging of quickly frozen food. We do not know what happens to wax when the temperature is taken down quite rapidly to very low temperatures; but that is where the petroleum people can help us quite a lot. In the future we shall have to deal with quite a lot of such foods, as the Americans are doing now.

Some recent experiments showed that the main trouble was the crystalline structure of wax. We do not know whether that structure is affected by the cooling, or whether the crystalline structure of paraffin wax is too big at the moment and will allow the moisture to come through on the thawing out of the quickly frozen food. That is a matter which is worrying me as a chemist, and I think the proposed joint committee of the petroleum and the paper interests will help us.

Another matter brought out by Mr Thorpe is that of hardness coupled with flexibility. He has mentioned that hardness is not akin to flexibility; and I quite agree. But—and I know this is a tall order—hardness and flexibility to the waxed-paper trade must go hand-in-hand. The creasing of waxed paper is something we must overcome, because it destroys quite 50 per cent of its value. Flexibility of the wax will get rid of that problem. The generally accepted idea about flexibility is that it will mean softer wax, so that flexibility will increase the scuffing and that will bring us

another trouble. Therefore, we hope the petroleum people will be able to investigate the matter and give us waxes which are harder and yet more flexible.

We have considered for some time the production of waxes with specialized properties, for at times we are asked for waxed papers having specialized properties, and we feel that the petroleum people could give us the necessary waxes. Indeed, they are already on the market; the properties required are covered practically completely by the nine special characteristics which are mentioned in the paper (p. 301).

I rather feel that the initiative rests first with the petroleum industry and secondly with the paper industry.

MR THORPE: Dr Mazee will be glad to know that the Institute's Sub-Committee on waxes is in contact with Dr Heald, who heads the TAPPI/ASTM group, and we are hoping to maintain close co-operation with them in their development work.

Oxidation stability is very important, and we are most interested in that problem. If anybody could talk on the problems which the wax users associate with oxidation inhibitors I should be glad. Some wax users making food packages are rather fearful of toxicity hazards arising from the use of oxidation inhibitors. There is a great demand for oxidation inhibitors for all waxes, but particularly, I think, for micro-crystalline waxes, which have not the same degree of oxidation stability as has paraffin wax. I feel that the differences in respect of oxidation stability are largely a matter of wax refining, and I think the acid treating of waxes does help their stability quite a lot. Micro-crystalline waxes, which have not good oxidation stability, are in general not acid washed.

I am interested in Dr Mazee's suggestions with regard to tensile strength; he has indicated an excellent approach to the matter. Personally I think it is illogical to determine tensile strength on relatively thick blocks of wax, and I am glad that Dr Mazee has referred to work which is on more logical lines.

He has said that he is not bothering to do the M.V.P. test on unsupported wax films. I think, however, that in developing waxes for specific purposes we ought to know more about M.V.P. We are brought back to the point raised by Mr Samuel when he asked if we put soaps into wax. Suppose we had put soaps into waxes, for some purpose, should we not endeavour to determine the effect of such additions on the M.V.P. of the unsupported wax film?

In regard to scuffing, there is in the section of the paper headed "Hardness" a brief reference to scuffing, and I try to associate it with hardness. There is a big development in the United States to blend such additives as polythene with waxes to reduce their scuffing tendency.

The contribution by Mr Webb is very interesting, and I agree that there is a lot to be done in connexion with the packaging of the quick-freeze foods. All the waxes I have met vary quite considerably in respect of their performance at low temperatures. During the war there was occasion to test the low-temperature performance of waxes for use on aircraft at temperatures in the order of −40° C. We made experiments in a cold room, and it was quite surprising to note the extent of the spontaneous

fracturing which occurred as the temperature dropped. Some of the micro-crystalline waxes can be taken down to −40° or −50° C without fracturing but, so far as I know, if paraffin waxes are brought down to temperatures of 10° F they may fracture. I think a lot has to be done in the attempt to modify those characteristics.

M. J. CURRAN: I hope that, when this proposed joint committee is formed to deal with specifications of waxes for waxed papers, the Packaging Division of the Printing and Allied Trades Research Association is brought in fairly quickly, so that the views of other large consumers of wax outside the paper trade can be fully considered. Amongst these interests, I would like to mention converters of regenerated cellulose film, plastic films, and aluminium foil.

I would also like the joint committee to bear in mind the fact that there is an increasing demand for waxes with resins incorporated and that the evaluation of their properties is very important, and should be allowed for in any specification that is drawn up.

DR E. G. V. BARRETT: My firm are concerned primarily with paraffin wax, and we have found there that, so long as there is good housekeeping, there is no difficulty with regard to oxidation stability. But from my experiments and investigations of the use of micro-crystalline waxes I find that in that case the story is quite different; in my opinion it is necessary to incorporate some oxidation inhibitor, especially when dealing with food containers.

It is surprising how very quickly this characteristic development of odour from oxidation occurs. I have carried out experiments in the laboratory and actually on the coating machine, and I have found that the micro-crystalline waxes, even the refined white micro-crystalline waxes, are more liable to oxidation; further, they are much more liable to the catalytic action of metals, such as iron or copper.

DR RICHARD ASCHER: In reply to the complaint that the wax producers do not supply the material for which the paper industry ask, we are in a rather difficult position. As you know, we in Great Britain, are allowed to import only a limited range of basic materials. In the United States, however, the amount of wax available to the paper industry is nearly unlimited, and the variety of paraffin and micro-crystalline waxes cannot be compared with what is available to us. Mr Thorpe's figures show how much larger the consumption of waxes is in America compared with Great Britain.

I believe that we could help the paper industry in a much higher degree if the paper converters would assist the wax producers and blenders in giving them the necessary information about the problems with which they are confronted. With a knowledge of the demands of the paper converters, the wax blenders will be able to produce materials which will meet their specific needs.

In collaboration with the industries which are in need of this material, we shall soon acquire the knowledge for developing the waxes which can be used to best advantage by the consumers.

MR THORPE: I was very interested in Dr Barrett's attitude towards oxidation stability. I wonder if you have had occasion to worry about the toxicity of the inhibitors normally used. Very often in the oil industry we associate oxidation inhibitors with some sort of phenol group. I know some people are rather worried that such oxidation inhibitors may be hazardous from the toxicity viewpoint. Has that problem arisen with you?

DR BARRETT: Naturally the problem has arisen or will arise because, inasmuch as such products are being used largely for foodstuffs wrappings, we have to give an assurance to the users that they will be free from trouble in that respect. We would rather pass that problem back to the suppliers of the anti-oxidants or to the oil industry.

MR THORPE: We must all face up to these things. In using oxidation inhibitors we will be faced, as the American people have been faced, with the problem of the toxicity hazard. What happened in America will happen here. The wax users will turn to the oil industry and ask if we can put an oxidation inhibitor into the wax. We will say "Yes," and the users will then ask whether it will meet the requirements of their particular "Food and Drugs Act," which stipulates that there must be no toxicity associated with it. This question can rarely be answered. My parent company in the United States, the Standard Oil Co. (New Jersey), have studied this problem very closely, and they find that most normal oxidation inhibitors have some degree of toxicity.

Once we become involved in such matters we will find it difficult to control them, because some badly refined waxes should be as suspect as the inhibitor.

I have a lot of sympathy with Dr Ascher's attitude. He is concerned with the blending of waxes. I have made the point in the paper that we must not get involved in restrictive specifications which prevent quality development in waxes and which may create unnecessary price increases. There must always be scope for the blending of waxes for specific purposes. I think the waxed-paper industry is to some extent blameworthy in not presenting the picture of what it does really want. The sort of co-operation that we shall get from industrial technical associations, such as are represented by Mr Underhay and Dr Riddell, and from individual companies will enable us to give some emphasis to the real properties that matter, and then we shall advance the cause of good packaging.

D. VICKERY: It seems to me that a point arising out of Mr Webb's remarks on the quick freezing of foods and the need for flexibility and hardness in the wax will have repercussions on the production side. If the need is for greater flexibility then the refiner will have to produce micro-waxes, *i.e.*, we shall follow the American pattern. In the United States the content of micro-waxes has gone up to quite high figures, more than 20 per cent in many cases, and other products—polymers, inhibitors, and so on—have been incorporated. We shall get a long way from the unmodified paraffin wax, which before the war formed the bulk of the wax production. As Mr Thorpe has pointed out, the development of solvent dewaxing methods will render micro-waxes available in quantity, a develop-

ment that most fortunately coincides with the realization that these micro-waxes possess marked flexibility at lower temperature, do not suffer from cracking on creasing, and thus satisfy requirements which cannot be met by ordinary paraffin wax.

S. T. MINCHIN: Mr Underhay will be interested to know that, apart from the Centigrade and Fahrenheit difficulty, Mr Thorpe's melting point is also really a setting point!

I think we all agree with the ideals expressed in Mr Thorpe's paper, and hope that that is feasible; yet the discussion this evening has shown up some of the difficulties. For example, Mr Thorpe points out in the paper that there is no known relationship between tensile strength and sealing; Dr Mazee has pointed out, and I strongly agree, that there is no definite relationship between hardness and blocking; and Mr Webb has said that there is probably no relationship between hardness and flexibility. Yet those in the petroleum industry are exhorted to develop tests of hardness, flexibility, and strength which will have some practical significance. Possibly they will not have a very easy time. I feel that the whole of this work will of necessity have to be backed by a good deal of fundamental investigation on the behaviour of waxes in the solid state.

But what do we mean by "hardness"? What kind of hardness; and even more so, what kind of flexibility? The thickness of film is of supreme importance there. I agree with Dr Mazee concerning the thinness of the specimens used in the tensile test. I agree wholeheartedly that we should get together to sort these things out, but I think it will be a big job of work which is likely to occupy several years.

I agree largely with what has been said in connexion with hardness and flexibility; but I do find, from the type of hardness test that I employ, that provided the waxes compared have about the same oil content, they give steep hardness curves.

With regard to the instability of the refined micro-crystalline waxes, I think it is a fact that some have an oil content of less than 2 per cent; probably they are acid-washed. I have a feeling that probably their lack of stability is at least partly due to the composition of the wax components and I imagine that for that reason some of the secondary and tertiary carbon atoms would be in a form which makes it easier to undergo some kind of oxidation. Although obviously refining must play some part, I am not at all certain that if they are refined they will not still be less favourable owing to the differences in composition. They are more branched and more cyclic than the normal paraffin waxes.

MR THORPE: I have a very great respect for Mr Minchin's views on waxes; perhaps he has done more work than most people in Britain on waxes, and when he says, as he does, that we have a big job before us in attempting to assess certain properties, we can be sure that such is the case. I have tried to give some sort of evaluation to the wax properties that are needed. I think that if we could all agree on what is No. 1 priority, in a year or two we may be able to get somewhere towards solving the difficulties relating to that one property. We have to start somewhere, and I would like the waxed-paper interests to put forward their views on priorities.

I was very interested in Mr Minchin's reference and his theory on oxidation stability of micro-waxes. I have not met a white micro-wax which has been acid-refined. So far as I know, the white micro-waxes have been the first runnings from bauxite or activated-clay treatment. I have had the view put to me by certain wax users, who are knowledgable on waxes, that the oil content affects stability, and they have gone so far as to try to assess the rate of oxidation of the oil they have extracted from some micro-crystalline waxes. That is very difficult because the amount extracted is quite small.

E. H. G. Sargent: Tests should really be done on a finished waxed paper. My experience of laminated products indicates that it is quite impossible to evaluate the properties of the laminate from an investigation of the properties of the two components. For example, the moisture-proofness of the paper and the resin can be evaluated, but they bear no resemblance whatever to the moisture-proofness of the laminated paper.

With regard to tensile strengths, the extension at break can be measured, and also the point where the material departs from the simple stress–strain relationship in its extension. I think that the information may tell you something about strength properties, *i.e.*, ductility and toughness, and possibly something about the blocking tendency, whereas the straight tensile test will not tell you very much.

A point in connexion with oxidation inhibitors is whether or not they will migrate from the wax to the product in the container. If they do not, then I do not think the question of toxicity is very important.

Dr T. Salomon: In France we have been working for several years on petroleum waxes for various uses, especially electrical uses in telecommunications, under the sponsorship of the French National Study Committee for Telecommunications (C.N.E.T.); most of the properties of waxes are equally important for use in the electrical industry and in the paper industry.

As regards oxidation stability, we found that refined paraffin wax is much less stable than refined pure micro-crystalline wax; paraffin wax oxidized in an open-air vessel with copper catalyst at 115° C gave high evaporation losses and acid values, where pure micro-crystalline wax produced very small and constant evaporation losses and much less acidity. This fact is in conflict with the different opinions given this evening. We observed one exception which may explain the opposite view: an ozokerite wax, of constitution very similar to that of micro-crystalline wax, heavily refined with sulphuric acid, had a very low oxidation stability. We found that the reason was the presence of sulphonation products in the wax; if that occurs, there will be rapid ageing.

The differences in mechanical and physical properties may arise from the special composition of the waxes; we know practically nothing about the behaviour of the oil, present in the wax, which may change according to the time of treating wax; it may be that the fixation in the intercrystalline spaces in the wax may change with time; as the crystalline structure of the wax is not very stable, the changes which may occur during long storage and by heating and cooling under different conditions may well explain the

difficulty of obtaining reproducible results when testing physical and mechanical properties of waxes. We are studying the nature of oil present in the waxes and its influence on the physical, chemical, and mechanical properties found.

DR BARRETT: With regard to oxidation, I think it is largely a question of usage. We do not have to bring our paraffin wax up to the temperature at which oxidation commences, but the micro-crystalline waxes generally have to be held at such a temperature that oxidation readily takes place. I think it probable if we had to use our paraffin waxes under the same conditions as those under which the micro-crystalline waxes are used, we should experience the oxidation difficulty with the paraffin waxes.

Further, it may be that, owing to the branch-chain structure of the micro-waxes, a small amount of oxidized material makes itself evident by reason of odour much more readily than in the case of the paraffin waxes.

DR MAZEE: I agree with Mr Minchin that the fundamental study of the crystalline waxes is necessary, and that the rheological behaviour of the waxes is very important. In the tests I have mentioned the relative elongation at the moment of break is measured, and the modulus of elasticity calculated.

In flexibility tests one measures only one point of the breaking of the wax under specified conditions and not the whole curve. If a bar of wax is bent slowly it does not break for some time, and when it is bent quickly it breaks more easily.

It would be necessary to measure the deformation as well as the rupture of the wax at all kinds of frequencies.

We have performance tests, and I think that fundamental work is necessary to explain the results of those tests. But we cannot wait for the results of the fundamental work, and must continue to apply performance tests for waxed papers in the meantime.

As to the oxidation stability of micro-waxes, sometimes micro-wax improves the oxidation stability of normal distillate wax, but that is so only if the micro-wax is not too highly refined; if it is refined too much, the oxidation stability decreases again.

Finally, I think that in the United States the use of certain inhibitors has been approved officially, presumably by the Bureau of Food and Agriculture.

T. N. GAUNT: Some five years ago we experienced a lot of trouble with the oxidation of waxes, and it became necessary to use inhibitors. Our investigations showed that very much less than 1 per cent are quite effective. The materials selected were fed to rabbits, guinea-pigs, and mice —for long periods—without any ill effects, and we have continued to use these inhibitors since that time without any ill effects whatever.

Waxed surfaces have a very pronounced tendency to accumulate dirt, and in shop windows may very soon appear extremely unsightly. Possibly the softness of the wax has a lot to do with that, and it is something that might well be investigated, because we know that wax cartons are ruled out by certain large companies in Britain for that reason.

With regard to the waterproofness of wax cartons, it is said that 1 per cent of lactic acid will eat through a carton very much more quickly than will water. I certainly agree, and I wonder whether Mr Thorpe has any suggestions to offer us as to why this is so.

With regard to the question concerning the use of soaps in wax blends, there are a number of patents covering the use of aluminium stearate in order to increase viscosity and hardness, and there are also some pre-war German patents covering the use of lithium stearate for such purposes.

Finally, concerning the suggested joint committee, is it quite reasonable that only the Paper Makers' Association should take part in this work with the Institute of Petroleum? I should imagine that a large amount of wax is used by paper converters who are not paper-makers, and who, therefore, may not be represented on the committee.

MR THORPE: I have no information on why lactic acid penetrates a waxed carton more rapidly than water. A test was developed for milk cartons, and it was found that butter fat tended to penetrate the cartons rapidly; if the milk became a little stale, it would go through more quickly. It was then suggested that rather than leave stale milk in the laboratory, a solution of lactic acid might be equally searching. The solution of lactic acid was found to act as well as the stale milk in breaking down the carton. So far as I know, the test continues to be widely used.

Mr Gaunt raised an important point when he referred to the degradation of waxed cartons in windows; I think that has a big bearing on the oxidation stability we have been discussing. We have talked glibly about oxidation, but do we mean acid development in the wax or the development of colour in the products? It seems to me that at least two processes are involved. The sunlight on a window will tend to raise the temperature and to soften the wax, but sunlight will also induce wax oxidation with darkening of the wax. It is also believed to be possible that wax oxidation leads to a softening of the wax with an increase in apparent oil content. We have to appreciate that petroleum products are subject mainly to two types of oxidation, which we in the oil industry have learned quite forcibly from transformer-oil use. At one time the British Standards Institution standardized two types of transformer oils, one being the B.30 grade and the other the A.30 grade; the B.30 grade was a moderately refined oil, and the A.30 was a highly refined oil from the same source. The more highly refined oil resisted colour change and sludge formation much more than did the less highly refined oil, which later produced a lot of sludge. But nowadays we do not like the highly refined transformer oils, and we prefer the less highly refined, because we are more worried about the acidity developed in the highly refined oils and would rather have sludge than acidity. There may be some relativity between the characteristics of transformer-oil oxidation stability and of wax stability which would be worth study.

EDWIN S. RAWSON: You have mentioned ceresin. There is a reference to ceresin in the British Pharmaceutical Codex—one can hardly call it a definition. In that connexion I would mention the experience of my own organization. We purchase ceresin or material which suppliers choose to

call "ceresin" and material which they call "paraffin wax." The two are almost indistinguishable in crystalline structure, and their melting points are much the same at about 50° C. Incidentally, I think Mr Minchin's remarks have convinced me that we should standardize our definitions before we go very far, because if, for instance, you ask six different people what is meant by "ceresin" you are likely to get half a dozen different answers. I believe the description of ceresin prior to 1914 was totally different from what it is to-day, so that if we look into the question of definitions it would help both sides.

MR THORPE: I agree entirely. So far as I know, ceresin was originally a refined ozokerite; but now it is often confused with micro-crystalline wax. Because "micro-crystalline wax" is a very poor definition, almost anything can be supplied as micro-crystalline wax, and it follows that almost anything can be supplied as ceresin. I have put up a suggested nomenclature, not as my idea of what it should be, but as something which the Institute of Petroleum at one time advanced in the hope that it would be of some help to the wax-producing and using industries. It does not seem to have received the attention it warranted, and we are still left with a pressing need to accept definitions for water.

A SPEAKER: Toxicity, too.

R. H. BLYTHE: May I bring in another interest—the education side of food technology, particularly in the meat trade. We are interested in this matter of packaging, particularly in view of the present-day efforts to achieve better hygiene.

For carcases I have seen experimental packages which are competitive with waxed paper. I am quite impartial, my concern being to secure more hygienic wrappers and containers. Some time ago I saw lamb packed in something which held in the moisture; although the carcases came out rather good looking, there had been a lot of extra moisture inside which dripped down, so that the carcases were not so good as they would have been in ordinary stockingette. I have not heard of wax being used with anything other than paper and cardboard, but if it is possible to use it to make a flexible covering it may be useful in the future. On the other hand, that proposition may be hopeless.

A. A. HALEY: With regard to the word "ceresine" this description was honestly used up to 1914, and possibly as late as 1920. It described a bleached ozokerite wax.

Under pressure from consumers it gradually came to mean a compound of white ozokerite wax with paraffin wax, most vaguely defined, and the quality depending on the price which the consumer was prepared to pay.

It has now become a term of most doubtful value, and the industry would be well advised to cut out the name "ceresine" from its vocabulary, as it frequently gives rise to misunderstandings.

The use of micro-crystalline waxes in combination with cotton "scrim" is in regular use, and special grades for Government specifications are in regular supply.

MR UNDERHAY: On this question of collaboration, I think there is no clear dividing line between paper-makers and converters; many manufacturers are converters, and many converters call themselves paper manufacturers. I feel that the way in which we endeavour to secure members for these specialist committees will ensure that the right people will serve. The procedure is to invite people in the industry to submit their names if interested in the project, so that when the committee is selected it will be representative. The people invited will include paper converters, of whom there is a large number in the membership of the Association.

M. J. CURRAN: One matter which has not been mentioned is the danger of waxes, or wax compounds, sweating through paper laminations under tropical storage conditions, which precludes their use for a number of products where the stain will offset and affect the quality of the commodity.

MR THORPE: I think that in the wax industry we refer to that trouble as "staining." Staining is often associated with wax sweating, that is, the tendency for wax to "bleed" oil at temperatures which, although elevated, are lower than the wax melting point. Some waxes sweat oil more easily than others. Micro-crystalline waxes, which are normally used for laminating, are very oil retentive, but they vary considerably among themselves. The subject of "staining" is, as Mr Curran has suggested, worthy of greater attention.

VOTE OF THANKS

THE PRESIDENT: I do not propose to put any resolution to you concerning the suggested co-operation on these problems, as I am sure Mr Thorpe will look after that, in his position as Chairman of the Wax Standardization Sub-Committee.

The only resolution I am going to put forward, and which I ask you to carry with your usual acclamation, is one to express our great pleasure in having Mr Thorpe here to-night and to let him know how much we all appreciate his paper, which has provoked such an interesting discussion. I will ask you to express your thanks to Mr Thorpe, and will give him the opportunity to make any particular point he wishes on the observations which have been put forward. We are grateful to him for the manner in which he had stimulated the discussion and has answered the questions put to him.

(The vote of thanks was carried with enthusiasm.)

MR THORPE, expressing his appreciation for the vote of thanks, said: I do feel that if only we in the oil industry can get closer to the packaging interests, then whatever efforts I have made in producing this paper will be well justified; and by the tone of the meeting I feel that we have made some progress in the right direction. I thank all those who are not in the oil industry for having come along to let us know how they feel about these matters. I hope you will appreciate how we in the oil industry feel towards you, and that this exchange of views will continue into the future.

STABILITY TEST OF MOTOR LUBRICANTS

By D. J. W. Kreulen (Fellow)

Summary

The merits of the strip test for the differentiation of motor lubricants have been examined. Some improvements were introduced, viz., stirring the oil in the central container, delivery of the oil by a heated capillary to ensure constancy of supply, and mounting the strip in a glass cylinder to protect it from air currents and to permit analysis of the evaporated oil.

Preliminary tests showed that among other things the material and the surface condition of the strip influenced the results, and a series of oils were investigated. The statement of McKee and Fritz that the test enables the distinguishing between regular, premium, and H.D. lubricants from the same base stock was confirmed.

Other oils were examined and a comparison was made with the I.P. oxidation test. It seems that the latter is of little value for the evaluation of modern additive-treated motor oils, and it is suggested the oxidation test should be replaced by the strip test.

In 1942 Stäger and Künzler [1] introduced a method for the evaluation of motor lubricants, in which a thin film of the oil was circulated over an electrically heated steel strip maintained at a fixed temperature. The test continued until the viscosity had increased to such an extent that circulation stopped. The residue was then analysed and the deposit on the strip evaluated by appearance and by its solubility in various solvents. It was noted that in both respects and in its ultimate analysis, the deposits were strikingly similar to those found in motor practice.

McKee and Fritz [2] of the U.S. National Bureau of Standards investigated this method for the distinguishing of additive-treated oils. As such oils are rated primarily upon engine deposits, the apparatus was designed primarily for the formation of characteristic deposits rather than for the study of changes in the oil.

After extensive experiments it was concluded that the correlation of the results with engine performance was of sufficient promise to justify further work.

It is obvious that a laboratory method which will rate lubricating oils, even if only primarily, is badly needed. Equally, it is true that eventually the decisive test is the engine. This does not mean that oils cannot be preliminarily rated in the laboratory, particularly as the strip test has been shown by Stäger and Künzler and by McKee and Fritz to give results which correlate with engine performance.

The present investigation was started with the Bureau of Standards apparatus, and the following modifications were made as the work proceeded.

Oil delivery to the strip was by means of an electrically-heated capillary, the temperature of which was hand-controlled by a regulator. This enabled the oil supply to be kept constant within narrow limits.

The contents of the central oil container was stirred to ensure that the oil returning from the strip was immediately mixed with the oil in the container.

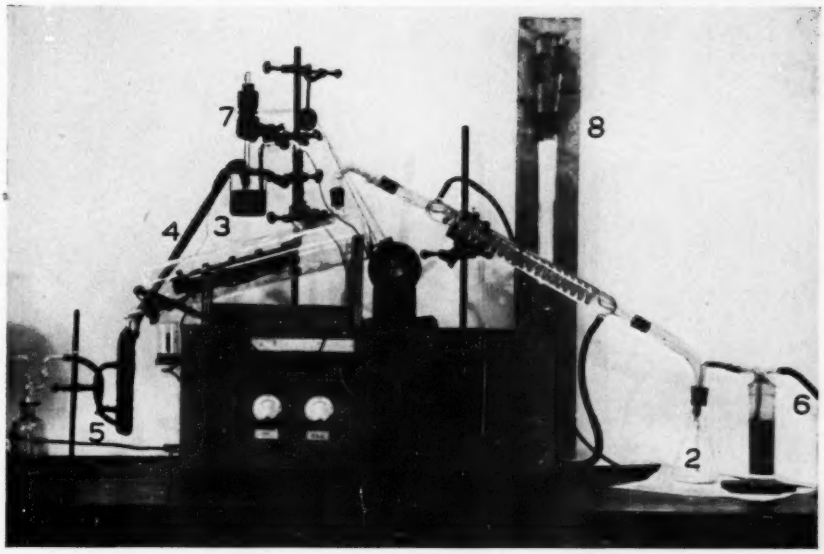

FIG. 1

1. AND 2. DISTILLATE.
3. CENTRAL OIL CONTAINER.
4. OIL LIFT.
5. AIR SUPPLY TO OIL LIFT.
6. CONNEXION TO PUMP.
7. STIRRING DEVICE.
8. FLOW METER TO CHECK AIR CURRENT.

[*To face p.* 316.

REGULAR PREMIUM H.D.

FIG. 3

The strip was clamped on the heating block by two steel bars. Waterglass was placed between the bars and the strip to make an oil-tight connexion and to prevent uncontrolled losses from the sides of the strip.

To render the test independent of extraneous air currents the apparatus was placed in a glass cylinder through which a constant air current was drawn by a vacuum pump. This also allowed the evaporated oil to be recovered for analysis.

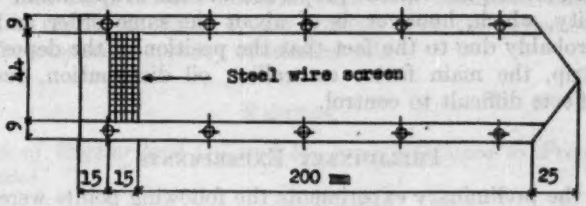

FIG. 2

The apparatus and the strip are shown in Figs. 1 and 2, and details of the test are :

Strip material—Light gauge structural steel.
Preparation of strip—Polish with carborundum powder (500 grit) and water. Clean also the back of the strip. Weigh the strip before mounting on the heating block.
Angle of inclination—15 deg from horizontal.
Temperature—250° ± 2° C as measured by a thermocouple touching the centre of the back of the strip.
Oil quantity—150 g.
Oil supply to strip—0·7 g/min (±2 per cent).
Air drawn through cylinder (*dia*, 80–85 *mm*)—5 l/min.

Procedure

Oil is circulated for a period of 12 hours or for two periods of 6 hours.

If the temperature of the strip is over 100° C at the commencement of the test, it should not take more than 10 minutes for it to reach the temperature of the test. No connexion is applied for this period.

During the early stages of the test periodical checks should be made that the strip is well covered with oil, and a bent glass rod may be used to ensure this. An uneven oil flow may be corrected by tilting the strip by means of the adjusting screws.

A light and a heavy distillate (Fig. 1, 1 and 2) are obtained during the test and are mixed together for analysis.

At the conclusion of the test the strip is removed, and drained over-night. It is then cleaned of oil by placing it in an inclined position with a piece of cotton gauze across the top. I.P. petroleum spirit is dropped on to the gauze, and when the spirit dripping from the strip is colourless the back of the strip is cleaned and the strip then dried and weighed.

To determine the evaporation, the contents of the central oil container are weighed at the conclusion of the test. This weight has to be corrected for oil remaining in the capillary and in the oil lift and for the oil obtained during the cleaning of the strip. With care during the test, the total loss does not exceed 5 per cent.

Assuming that evaporation amounts to 30 per cent and that the evaporation/time relationship is linear, the quantity of oil in circulation half-way through the test is $150 - 22{\cdot}5 = 127{\cdot}5$ g. As the oil is supplied to the strip at 0·7 g/min., this means $0{\cdot}7 \times 60 \times 12 = 504$ g in total, and that the oil passes over the strip $504/127{\cdot}5 \cong 4$ times. Consequently, a higher evaporation means a more intensive heat treatment of the oil during the test. This gives an uncertain element in comparing oils having different

evaporation, and in such cases might be expressed after the oil has passed over the strip the same (average) number of times.

Viscosity, Conradson value, ash, acid value, and ester value (saponification number minus acid value) are determined by I.P. methods. Methods described by the author are used for carbonyl value[3] and peroxides.[4]

Repeatability of the test is within 20 per cent, whilst there is direct correlation between the various properties and the evaporation. The poor repeatability, which, however, is of about the same order as for engine tests, is probably due to the fact that the position of the deposits formed on the strip, the main factor controlling oil distribution, results from random effects difficult to control.

Preliminary Experiments

During the preliminary experiments the following points were noted :—

1. No asphalt is formed if the test is carried out at 250° C under the prescribed conditions.

2. When evaporation, weight of strip deposit, or constants of the residue are plotted as a function of time, the relationship is linear or nearly so. Thus, any period of time may be chosen, and 12 hours was selected as a reasonable period and as ensuring easily measurable changes in the oil constants.

3. When an oil is readily oxidizable, the viscosity index of the residue is appreciably lower than that of the fresh oil. This is not due to the evaporation of light fractions with a high V.I., as it was also observed with oils in which, after steam distillation, the residue and the distillate had the same V.I.

Table I

Oil		Deposit on strip, mg	Distillate			Residue			
			Acid value	Ester value	Carbonyl value	Conradson increase	Acid value	Ester value	Carbonyl value
VI	Polished steel	220	3·0	9·0	10	0·9	1·5	7·0	8·0
	Dull steel	430	2·4	6·8	13·4	1·0	1·3	7·0	6·0
	Dull glass	470	4·7	16	21	1·3	1·0	8·6	6·5
IX	Polished steel	68	2·2	5·4	9·0	0·5	1·1	3·7	3·3
	Dull steel	80	1·9	6·5	8·7	0·7	1·0	4·3	3·8
	Dull glass	102	3·2	6·6	10·5	1·2	1·4	4·5	5·3
I	Polished steel	500	16	20	34	0·5	3·0	10	11
	Dull steel	730	14	28	43	0 6	2·7	8·4	11·3
	Dull glass	2000	18	33	50	1·1	2·8	13	13

4. As engine-cleaning properties are claimed for H.D. oils, the cleaning of a dirty strip was attempted in a test with an H.D. oil. Results showed no cleaning : on the contrary a small increase in weight was observed. Apparently H.D. oils do not loosen fixed deposits and their action is limited to keeping in dispersion solids which would otherwise be deposited. The cleaning activity of H.D. oils may be due to the fact that most engine deposits are oil-soaked sludges readily dispersed by detergents.

5. The nature of the strip deposits is under investigation.[5] It need only be noted here that the compounds are characterized by very high (several hundreds) saponification numbers.

6. The effect of surface condition (polished or dull) on the quantity of deposit was investigated. Tests using strips of polished steel, dull ground steel, and dull ground glass at a same surface temperature, viz., 254° C (melting point of sodium formate) gave the results set out in Table I. It is evident that both surface material and strip condition influence the results. The results in Table I also confirm that the presence of glass increases the oxidation velocity of mineral oils.[6]

Results

Comparison of Regular-type Oil and the same oil Doped to Premium and H.D. grades

The base oil was a solvent-refined distillate. The appearance of the strips (Fig. 3) and the results given in Table II confirm the statement by

Table II

Results Obtained from a Regular, Premium, and H.D. Type of Lubricating Oil Originating from a Same Base Stock

Fresh oil :	I regular	II premium	III H.D.
Kinematic viscosity, cs :			
100° F	117	114	113
50° C	62	62	62
210° F	11·7	11·5	11·4
Viscosity index	96	95	95
Conradson value, %	0·01	0·16	0·47
Ash, %	0·00	0·07	0·39
Conradson minus ash, %	0·01	0·09	0·08
Results of Strip Test			
Residue :			
Conradson minus ash, %	0·5	0·4	0·3
Acid value, mg KOH/g	3	2	1
Ester value, mg KOH/g	10	6	5
Carbonyl value, mg KOH/g	11	5	3
Peroxides, mg O_2/g	0·3	<0·1	<0·1
Distillate :			
Conradson minus ash, %	0·1	0·1	0·1
Acid value, mg KOH/g	16	6	3
Ester value, mg KOH/g	20	9	6
Carbonyl value, mg KOH/g	34	12	6
Peroxides, mg O_2/g	2	1	0·2
Results summarized as : $\frac{\%\text{ evaporation} \times \alpha + \%\text{ residue} \times \beta}{100}$ where α and β are the values for the constant in question of distillate and residue respectively.			
Evaporation, %	20	25	25
Deposit on strip, mg	500	270	50
Increase in Conradson minus ash, %	0·4	0·2	0·1[8]
Acid value, mg KOH/g	5·6	3	1·5
Ester value, mg KOH/g	12	6·8	5·3
Carbonyl value, mg KOH/g	16	6·8	3·8
Peroxides, mg O_2/g	0·6	0·3	0·1

McKee and Fritz [2] that regular, premium, and H.D. oils can be distinguished by this test.

It is of interest that the different behaviour of the oils on the strip is reflected in the state of oxidation of the distillate. In this connexion, an action of the additives in the vapour phase might be considered, but it is more likely that the changes occur at the liquid/strip interface. The results in Table I point in this direction, and further investigations might be of value.

Comparison of Regular-type Oils of Varying V.I.

Results are given in Table III, in which Oil IV is an ordinary machine oil, Oil V a Mid-Continent oil, Oil I a regular paraffin-base oil (solvent

TABLE III

Results Obtained from a Series of Regular Type Lubricants of Various Viscosity Indices

Fresh oil :	IV	V	I	VI
Kinematic viscosity, cs :				
100° F	110	122	117	107
50° C	57	65	62	62
210° F	9·1	10·9	11·7	11·5
Viscosity index	45	76	96	102
Conradson value, %	0·02	0·2	0·01	0·6
Ash, %	0·00	0·00	0·00	0·00
Results of Strip Test				
Residue :				
Conradson value, %	2·1	1·8	0·5	1·5
Acid value, mg KOH/g	1·7	2·5	3	1·5
Ester value, mg KOH/g	8·4	10	10	7
Carbonyl value, mg KOH/g	11	14	11	8
Distillate :				
Acid value, mg KOH/g	1·7	3·5	16	3
Ester value, mg KOH/g	1·8	7	20	9
Carbonyl value, mg KOH/g	11	14	34	10
Results summarized as : $\frac{\%\text{ evaporation} \times \alpha + \%\text{ residue} \times \beta}{100}$ where α and β are the values for the constant in question of distillate and residue respectively.				
Evaporation, %	62	43	20	29
Deposit on strip, mg	540	340	500	220
Increase in Conradson value, %	0·8	0·8	0·4	0·5
Acid value, mg. KOH/g	1·7	2·9	5·6	1·9
Ester value, mg KOH/g	4·9	8·7	12	7·6
Carbonyl value, mg KOH/g	11	14	16	8·6

refined), and Oil VI a regular pure Pennsylvanian. The different behaviour of the solvent-refined (I) and the non-solvent-refined (V and VI) oils is striking. If an extra anti-oxidant is anywhere required it is in a solvent-refined oil, as during solvent refining part of the natural oxidation inhibitors are removed.

The non-solvent-refined oils in Table III show two trends, a decrease of both evaporation and strip deposit with increasing V.I. That the volatility (oil consumption) of an oil is related to V.I. is also known in motor practice.

The other data in Table III are given for a first orientation only. A further application of this test in practice will give additional information leading to more detailed interpretation later.

Premium-type Oils of Similar Viscosity

In order to determine results which might be obtained in the comparison of highly refined oils which had passed engine tests before marketing, four premium-type motor oils of about the same viscosity were examined.

Results are given in Table IV. As the ash contents show, oils VIII and X are both also slightly detergent doped.

TABLE IV

Results Obtained from Four Well-known Brands of Premium-type Lubricating Oils

Fresh oil :	VII	VIII	IX	X
Kinematic viscosity, cs :				
100° F	113	118	104	108
50° C	62	65	58	62
210° F	12·4	12·1	12·1	13·1
Viscosity index	108	99	111	119
Conradson value, %	0·2	0·3	0·5	0·3
Ash, %	traces	0·1[5]	traces	0·1[5]
Conradson minus ash, %	0·2	0·2	0·5	0·2
Results of Strip Test				
Residue :				
Conradson minus ash, %	0·7	0·3	1·2	0·3
Acid value, mg KOH/g	1·1	0·5	1·1	0·6
Ester value, mg KOH/g	3·9	0·8	3·7	0·9
Carbonyl value, mg KOH/g	2·8	1·6	3·3	1·7
Distillate :				
Acid value, mg KOH/g	3·0	0·8	2·2	1·5
Ester value, mg KOH/g	6·2	3·1	5·4	2·5
Carbonyl value, mg KOH/g	5·5	4·2	9·0	5·0
Results summarized as : $\frac{\%\text{ evaporation} \times \alpha + \%\text{ residue} \times \beta}{100}$ where α and β are the values for the constant in question of distillate and residue respectively.				
Evaporation, %	21	17	37	30
Deposit on strip, mg	175	113	68	30
Increase in Conradson minus ash, %	0·4	0·1	0·4	0·0
Acid value, mg KOH/g	1·5	0·6	1·5	0·9
Ester value, mg KOH/g	4·4	1·2	4·3	1·4
Carbonyl value, mg KOH/g	3·3	2·0	5·4	2·7

Premium-type Oils of Increasing SAE Numbers

Two premium-type oils of increasing SAE Numbers were examined, and the results are given in Table V. Though the oxidizability tends to decrease as the SAE Number increases, the deposit on the strip is not always similarly related to viscosity. This is illustrated in Fig. 4.

Apparently the use of a more viscous oil does not necessarily produce more deposits. Each case needs to be investigated separately, especially where additive treated oils are concerned.

TABLE V

Results Obtained from Successive SAE Viscosity Grades of Two Premium-type Lubricating Oils

Fresh oil:	IX			VIII		
SAE:	10	30	40	10	30	40
Kinematic viscosity, cs:						
100° F.	46	104	146	45	118	149
50° C.	27·7	58	78	27	65	78
210° F.	6·8	12·1	14·8	6·6	12·1	13·9
Viscosity index	111	111	108	111	99	97
Conradson value, %	0·2	0·5	0·7	0·2	0·3	0·4
Ash, %	traces	traces	0·1	0·1[5]	0·1[4]	0·1[5]
Conradson minus ash, %	0·2	0·5	0·6	0·0[5]	0·2	0·3
Results of Strip Test						
Residue:						
Conradson minus ash, %	1·1	1·2	1·2	0·2	0·3	0·5
Acid value, mg KOH/g	1·5	1·1	0·9	0·8	0·5	0·5
Ester value, mg KOH/g	5·9	3·7	4·1	2·6	0·8	0·8
Carbonyl value, mg KOH/g	4·6	3·3	4·1	2·1	1·6	1·8
Distillate:						
Acid value, mg KOH/g	2·7	2·2	2·1	1·1	0·8	1·1
Ester value, mg KOH/g	6·4	5·4	6·8	2·7	3·1	1·4
Carbonyl value, mg KHO/g	9·5	9·0	7·8	3·6	4·2	3·2
Results summarized as: $\frac{\%\text{ evaporation} \times \alpha + \%\text{ residue} \times \beta}{100}$ where α and β are the values for the constant in question of distillate and residue respectively.						
Evaporation, %	52	37	28	34	17	12
Deposit on strip, mg.	117	68	58	70	113	115
Increase in Conradson minus ash, %	0·4	0·4	0·4	0·1	0·1	0·1
Acid value, mg KOH/g	2·1	1·5	1·2	0·9	0·6	0·6
Ester value, mg KOH/g	6·2	4·3	4·9	2·6	1·2	0·9
Carbonyl value, mg KOH/g	7·1	5·4	5·1	2·6	2·0	2·0

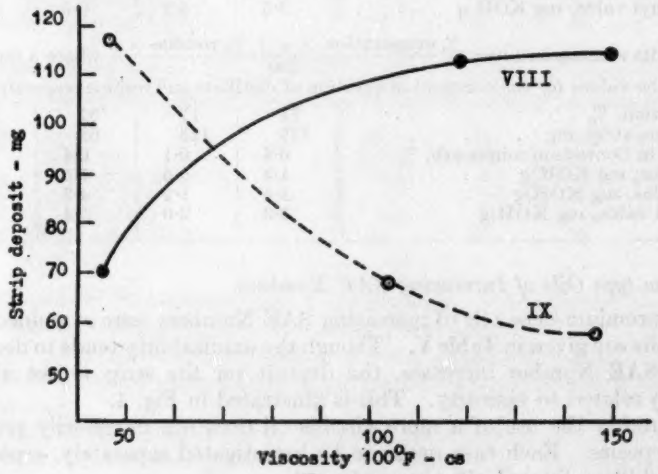

FIG. 4

Comparison with I.P. Oxidation Test

The next step was to compare the strip test with the I.P. oxidation test. For this purpose the acid, ester, and carbonyl values were determined in addition to the viscosity ratio and increase of carbon residue (corrected for ash).

Results are given in Table VI, and it appears that the I.P. oxidation test,

TABLE VI

Comparison of Strip Test with I.P. Oxidation Test

	I		II		III		IV		V	
	*	†	*	†	*	†	*	†	*	†
Conradson minus ash (increase), %	0·4	0·8	0·2	0·5	0·1[1]	1·3	0·8	1·0	0·8	0·8
Viscosity ratio	2·0	1·4	1·7	1·2	1·5	1·3	3·6	1·9	5·2	1·8
Acid value, mg KOH/g	5·6	2·5	3·0	1	1·5	2·7	1·7	1·1	2·9	1·4
Ester value, mg KOH/g	12	12	6·8	4·2	5·3	6·8	4·9	5·6	8·7	6·6
Carbonyl value, mg KOH/g	16	5·8	6·8	2·4	3·8	0·8	11	1·9	14	4·1
	VI		VII		VIII		IX		X	
Conradson minus ash (increase), %	0·5	0·9	0·4	0·7	0·1	1·1	0·4	1·9	0·0	2·0
Viscosity ratio	2·2	1·5	1·8	1·3	1·3	1·4	2·3	1·9	1·5	1·6
Acid value, mg KOH/g	1·9	1·2	1·5	1·0	0·6	1·7	1·5	2·8	0·9	2·2
Ester value, mg KOH/g	7·6	6·6	4·4	4·8	1·2	5·6	4·3	7·3	1·4	8·2
Carbonyl value, mg KOH /g	8·6	4·4	3·3	2·7	2·0	3·8	5·4	4·6	2·7	4·4

* Strip test. † I.P. oxidation test.

in the present state of knowledge of lubricating oil, has little value for the evaluation of these oils, for it does not even distinguish premium-type lubricants from ordinary machine oils. This may be due to the presence of additives in modern lubricants, and this may also be responsible for the inconsistent results when H.D. oils are subjected to the I.P. test. A change to the strip test, even with its imperfections, would be an important improvement.

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[3] Kreulen, D. J. W., and Kreulen-Van Selms, F. G. *J. Inst. Petrol.*, 1948, **34**, 932.
[4] Kreulen, D. J. W. *J. Inst. Petrol.*, 1946, **32**, 517.
[5] Van der Minne, J. L. To be published.
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Rotterdam,
Laboratory for Oil and Coal Chemistry.

THE INSTITUTE OF PETROLEUM

ANNUAL REPORT

For the Year Ending December 31, 1950

MEMBERSHIP

Details of membership as at December 31, 1950 :—

	Total Dec. 31, 1949	Changes during 1950						Total Dec. 31, 1950
		New	Transferred to	Resigned	Deceased	Transferred from	+ or −	
Hon. Members	8	—	—	—	2	4	− 6	2
Hon. Fellows	3	2	4	—	2	—	+ 4	7
Members	638	23	5	48	5	7	− 32	606
Fellows	518	38	6	10	6	—	+ 28	546
Assoc. Members	767	61	1	69	3	9	− 19	748
Assoc. Fellows	320	120	18	4	1	1	+132	452
Students	194	20	—	23	—	13	− 16	178
Totals	2448	264	34	154	19	34	+ 91	2539
Member-Companies	150	19	—	3	—	—	+ 16	166

DEATHS

The following deaths are recorded with regret :—

A. L. Beall (F.).
A. G. V. Berry (F.).
A. W. Eastlake (Hon. F.).
B. Engel (F.).
A. J. Forrest (M.).
G. T. Kennedy (A.F.).
W. G. Langford (A.M.).
R. G. Longcroft (M.).
J. T. V. Miller (M.).
W. F. Murray (M.).
L. Pineau (Hon. F.).
R. Sadek Pasha (Hon. M.).
A. Smith (M.).
J. Templeton (F.).
G. Thompson (F.).
R. R. Tweed (F.).
L. K. White (A.M.).
S. H. Wilkinson (A.M.).

Mr Arthur Eastlake was a founder-member of the Institute, and served for many years as Honorary Secretary. Col. Pineau had been an Honorary Member and later an Honorary Fellow for twenty-two years.

Mr Berry was an *ex-officio* member of Council representing the Stanlow Branch.

Mr J. Kewley was elected an Honorary Fellow during the year, and Col. L. Pineau (since deceased), Sir Harry Ricardo, Prof. L. Ubbelohde, and Prof. H. I. Waterman were transferred from Honorary Membership to Honorary Fellowship.

Although Corporate membership has steadily increased, Council feels that the rate of increase is not as rapid as it should be, having in mind the wide expansion of the petroleum industry in the country.

Members are reminded that membership is no longer confined to those with technical qualifications. Applications for membership will be welcomed from anyone engaged in the petroleum, or an allied industry, who is qualified by experience in accordance with the by-laws. With the co-operation of individual members, it is felt that the target of 4000 corporate members can be attained.

General

General Meetings

Eleven General Meetings were held during 1950—the subjects covering a very wide field. The average attendance was eighty—a great improvement on 1949 (fifty).

Annual Dinner

The Annual Dinner was again held at the Savoy Hotel in February, the attendance reaching the record figure of 540.

Oil Shale Conference

The Second Oil Shale and Cannel Coal Conference was held in Glasgow during July, under the auspices of the Institute and organized by the Scottish Branch.

A total of forty-eight papers were presented and will be published in full, with a report of the discussion, as soon as practicable.

Attendance at the conference totalled about 200, and included several representatives from the U.S. Bureau of Mines, who also contributed valuable papers on the experimental work in progress on the production of oil from shale. In addition, there were delegates from many other countries. The discussions which followed the presentation of the papers were of high calibre.

Those responsible for its organization are to be congratulated on a most successful Conference.

Third World Petroleum Congress

The Institute has been actively concerned, through the British National Committee, in the collection of papers in U.K. for the Third World Petroleum Congress, to be held in the Hague in June 1951. The activities of the General Reporters have been co-ordinated by the Editor, and the General Secretary of the Institute has continued to act as General Secretary of the Permanent Council of the World Petroleum Congress.

Representation on Other Bodies

The Institute has been represented by members of Council and other members on a very large number of other bodies. Council attaches much importance to maintaining close contact with the work of kindred societies and with the British Standards Institution.

Studentships

Mr R. H. Hill and Mr J. C. M. Taylor were elected to the annual scholarships offered by the Institute at Birmingham University and the Imperial College of Science and Technology respectively.

Benevolent Fund

Only one call has been made on the Benevolent Fund during 1950. There is still need to increase the reserves of this fund, and members are invited to forward subscriptions or donations to the General Secretary.

Branches and Students' Section

Corporate Membership of Branches has increased, and Branch Membership has been well maintained.

All Branches have held regular meetings which have been well attended.

By-Laws

The By-Laws Committee has been concerned mainly with a change in the Memorandum of Association of the Institute, made so as to enable the latter to be re-admitted to the legal status of a charity, with consequent benefits in connexion with tax liability.

The necessary alterations to the Memorandum were drafted by the Institute's solicitors and, after having been approved by Council, were put to a Special General Meeting of members held on February 27, 1950, at which meeting these changes were adopted.

Changes were also made to Article 23 of the Articles of Association and to By-Law 65; these deal with the period of service and retirement of members of Council and Vice-Presidents respectively. The object of such changes was to remove doubts and difficulties that had occasionally arisen in the past in connexion with these matters. These changes were likewise adopted by members at the above-mentioned Special General Meeting.

Certain alterations were made in the composition of the committee, and opportunity was taken of ensuring that there should be a certain degree of common membership between the By-Laws and Election Committees.

Engineering Committee

The *Electrical Code* has been revised and published.

The Committee is now engaged on the preparation of further safety codes covering Marketing, Refining, and Production.

Publications

Journal.—Volume 36 of the *Journal* was issued in twelve monthly parts. It contained 758 pages (847 in 1949) of *Transactions*, and 611 pages of *Abstracts* (412 in 1949), an aggregate of 1369 pages compared with 1259 in Volume 35.

There were fifty-two individual papers in *Transactions* Section of the *Journal* and, on a broad classification, their subject-matter concerned :—

Production	5
Refining	3
Physics and chemistry	13
Analysis and testing	26
Utilization	5

In comparison with 1949 the number of abstracts published in 1950 showed an increase of nearly 53 per cent in number and by 48 per cent in pages occupied.

Details of the number of abstracts in the main classifications are :—

	1949		1950	
	No.	Per cent	No.	Per cent
Exploration and exploitation	461	24·9	998	35·3
Transport and storage	101	5·5	112	4·0
Refining operations	398	21·5	550	19·4
Products	651	35·1	805	28·4
Corrosion	—	—	58	2·0
Engines and equipment	115	6·2	131	4·6
Safety precautions	—	—	39	1·4
Miscellaneous	127	6·8	138	4·9
Total	1853	100·0	2831	100·0

It is of interest to note that, while there were increases in every group, the largest was in the case of abstracts dealing with exploration and exploitation.

In general, it can be said that the very considerable increase in this valuable feature of the *Journal* is due to the re-organization by the Abstracts Sub-Committee of the Abstracts Groups and the interest which the abstractors take in their work. Council is much indebted to them.

In addition to the abstracts, this section of the *Journal* contained seventeen critical reviews of new books and seventy-five references to books received for inclusion in the Library.

I.P. Review.—The total number of pages in the twelve issues of the *I.P. Review* which made up Volume 4 was 416, compared with 396 in 1949, both inclusive of advertisements, but excluding the four title-pages.

It is gratifying to have to report that many members have paid personal tribute to the attractiveness of the *I.P. Review* and its contents. It certainly seems that this publication is well-read by members, although outside sales are not yet of any magnitude.

Petroleum Technology.—Volume 9, covering 1947, was issued during the autumn after considerable delay due to the authors having failed to deliver their manuscripts by the promised date. Sales to the end of the year were approximately 450 copies out of a total edition of 1000.

It had been hoped to issue Volume 10 (1948) during the year, but pressure of work in the Division and the delay in the receipt of manuscripts has prevented publication before March 1951.

Research

During the year close attention has been given to the extension of the activities of the Hydrocarbon Research Group and to the encouragement of similar work to that being carried out by the A.P.I., with whom contact has been established on the possibility of co-operation in the preparation of standard hydrocarbon samples. The sponsors of the Group have been increased by the addition of Manchester Oil Refinery Ltd. and Monsanto Chemicals Ltd.

The Hydrocarbon Synthesis Panel has continued its work at the various centres, the synthesis of specific hydrocarbons having given place to more general studies of hydrocarbon reactions and properties. The Spectroscopic Panel held a symposium and exhibition on spectroscopic methods in hydrocarbon research in December, and the Mass Spectrometry Panel's Conference in Manchester in April was well attended.

Committee No. 2 on carcinogenicity has continued to collaborate with the Medical Research Council, and oils have been fractionated and are now under biological examination. The committee of the Ministry of Labour has adopted a specification for white oils for use in the textile industry, this having been drawn up in full collaboration with the petroleum industry. Full support has also been given to the symposium on the chemistry of cell divisions which, although interrupted by the sudden death of Prof. G. A. R. Kon, F.R.S., during the conference, continues to pursue its purpose.

Standardization

The work of the Standardization Committee, which is such an important phase of the Institute's activities, has continued steadily, and a new edition of "Standard Methods of Testing Petroleum and its Products" was sent to the printers before the end of the year.

Mr H. Hyams paid a visit to New York, primarily for discussions concerning closer co-operation between the Institute and A.S.T.M.

Finance

Income from members' subscriptions rose to well above £16,000, about £3000 more than in 1949. This was accounted for by a steady increase in the number of Corporate members, the application of the new rates for Corporate members, and the continued support of Member Companies; these latter subscribed £1000 more than in 1949.

Expenditure rose by nearly £2000 compared with the previous year. An item under "Staff Pensions" appears for the first time, the sum

involved being £700. The strengthening of the staff to meet the expanding activities of the Institute, and normal salary increments added nearly £800 to administration expenses. Rising costs and increasing activities added considerably to printing, stationery, and postage; and the meetings organized by the Institute cost us £220 more in 1950 than in the previous year.

The Institute is warmly appreciative of the financial encouragement given to it by all its members, which has enabled us once again to carry forward a balance into our Reserve Account.

Acknowledgments

The Council again wishes to record its appreciation of the work of the General Secretary, the Editor, the Technical Secretary, and their staffs, throughout the year.

March 1951

By Order of the Council,
C. Chilvers, Hon. Secretary.

THE INSTITUTE

(A Company limited by Guarantee

BALANCE SHEET AS

CAPITAL AND RESERVES	£ s. d.	£ s. d.	*1949* £
Capital of the Institute under Bye-Laws 36, 44, and 45 :—			
Life Membership Fund—			
As at December 31, 1949	939 6 6		*939*
Entrance and Transfer Fees—	£ s. d.		
As at December 31, 1949	5653 17 9		
Add Receipts during 1950—			
Entrance Fees	241 10 0		
Transfer Fees	3 3 0		
	5898 10 9		*5654*
Profit on Sale of Investments—			
As at December 31, 1949	257 19 4		*258*
Donations—			
As at December 31, 1949	326 5 0		*326*
		7422 1 7	*7177*
T. C. J. Burgess Prize Fund		5 0 0	*5*
General Reserve (previously War Contingencies Reserve)		1702 0 11	*1702*
Revenue Account :—			
As at December 31, 1949	5680 19 6		
Add Surplus for year to date	2782 19 9		
		8463 19 3	*5681*
Subscriptions Received in Advance :—			
Members' Subscriptions for 1951	1426 17 6		
Members' Subscriptions for 1952	3 0		
Member-Company Subscriptions for 1951	367 5 0		
Journal Subscriptions for 1951	861 4 1		
Journal Subscriptions for 1952 and 1953	44 4 6		
		2699 14 1	*4174*
Current Liabilities :—			
Sundry Creditors and Accrued Charges	1077 16 7		
World Petroleum Congress	198 14 7		
Third World Petroleum Congress Appeal, 1951	1710 0 0		
		2986 11 2	*1630*
Sum Set Aside for Grants to Branches and Students' Section—unallocated		110 0 0	—

Approved by the Council :—
C. A. P. SOUTHWELL, *President.*
G. H. COXON, *Hon. Treasurer.*

£23,389 7 0	*£20,369*

AUDITORS' REPORT TO THE MEMBERS

We have examined the above Balance Sheet and annexed Revenue Accounts and report as

(1) We have obtained all the information and explanations which to the best of our knowledge and belief were necessary for the purposes of our audit.

(2) In our opinion proper books of account have been kept by the Institute, so far as appears from our examination of those books.

(3) The Balance Sheet and Revenue Account are in agreement with the books of Account.

We have accepted a Certificate from the Institute's Bankers for the Securities held by them on behalf

116, OLD BROAD STREET,
LONDON, E.C. 2. *April* 6, 1951.

OF PETROLEUM

and not having a Share Capital)

AT DECEMBER 31, 1950

		£ s. d.	£ s. d.	1949 £
FIXED ASSETS				
Investments :—				
On Account of Capital at cost—				
£525 0 0 3%	Savings Bonds, 1955/65	525 0 0		
867 8 6 2½%	Bristol Corporation Redeemable Stock, 1955/65	845 17 7		
150 0 0 3%	Smethwick Corporation Redeemable Stock, 1956/58	151 4 9		
150 0 0 3%	Luton Corporation Redeemable Stock, 1958	151 6 7		
806 8 3 3%	Manchester Corporation Redeemable Consolidated Stock, 1958	845 17 7		
600 0 0 3%	Bristol Corporation Redeemable Stock, 1958/63	597 7 3		
664 6 6 3%	London County Consolidated Stock, 1920	481 10 6		
400 0 0 3%	Metropolitan Water Board "A" Stock, 1963	346 10 7		
193 0 0 3%	British Gas Guaranteed Stock, 1990/95	154 8 6		
156 9 8 3%	British Transport Guaranteed Stock, 1978/88	105 4 9		
461 0 0 2½%	Funding Loan, 1956/61	461 15 6		
500 0 0 2½%	Defence Bonds	500 0 0		
	(Market Value at December 31, 1950, £5201.)	5166 3 7		*5166*
	Cash on Deposit with Post Office Savings Bank	2255 18 0		*1573*
			7422 1 7	
On Account of Revenue, at cost—				
£2942 2 9 3%	Savings Bonds, 1955/65	2975 0 0		
2000 0 0 3%	Savings Bonds, 1960/70	2000 0 0		
			4975 0 0	*2475*
	(Market Value at December 31, 1950, £4962.)			
Office and Library Furniture at cost, less amounts written off :—				
	As at December 31, 1949	1071 2 2		
	Add Additions during 1950	244 3 11		
		1315 6 1		
	Less Depreciation provided for year to date	131 10 7		
			1183 15 6	*1071*
			13,580 17 1	*£10,285*
Current Assets :—				
	Stock of Publications in hand as certified by the General Secretary	1698 2 10		*1568*
	Sundry Debtors and payments in advance, including Income Tax recoverable	1998 2 0		*2709*
	Hydrocarbon Research Group	275 0 0		—
	Subscriptions in arrear (not valued)	— — —		—
	Cash at Bank on Current Account and in hand	4160 7 6		*3543*
	Cash on Deposit with Post Office Savings Bank—			
	General Account	1478 3 0		*1984*
	World Petroleum Congress	198 14 7		*280*
			9808 9 11	
			£23,389 7 0	*£20,369*

OF THE INSTITUTE OF PETROLEUM

follows :—

(4) In our opinion, to the best of our information and according to the explanations given to us :—

(a) The accounts give the information required by the Companies Act, 1948, in the manner required.

(b) The Balance Sheet gives a true and fair view of the State of the Institute's affairs at December 31, 1950.

(c) The Revenue Account gives a true and fair view of the revenue for the year ended December 31, 1950.

of the Institute.

GRAHAMS, RINTOUL, HAY, BELL, & Co.
Chartered Accountants.
Auditors.

THE INSTITUTE

REVENUE ACCOUNT FOR THE

	£ s. d.	£ s. d.	1949 £
To Administrative Expenses :—			
Staff Salaries and National Insurance	7934 18 2		*7269*
Staff Pension Scheme Contributions	738 2 3		—
	8673 0 5		
Less Applicable to Publications	2768 9 1		—
	5904 11 4		
Printing and Stationery	799 10 2		*738*
General Postages	500 13 3		*430*
Telephones, Cables, and Travelling Expenses	219 18 3		*230*
Audit Fee	73 10 0		*74*
Legal Fees	—		*30*
General Expenses	247 15 2		*378*
Insurance	27 2 0		*33*
		7773 0 2	
„ Establishment Expenses :—			
Rent, less amounts recovered	2500 0 0		*2500*
Cleaning, Lighting, and Heating	423 7 1		*413*
Repairs and Maintenance	50 14 0		—
	2974 1 1		
Less Applicable to Publications—one-fourth	743 10 3		—
		2230 10 10	
„ Meetings :—			
Hire of Hall, Pre-Prints, Reporting, etc.		607 0 1	*379*
„ Sum Set Aside for Grants to Branches and Students' Section		500 0 0	*465*
Grants made :—			
Scottish Branch	30 0 0		
Northern Branch	145 0 0		
London Branch	70 0 0		
Stanlow Branch	25 0 0		
Trinidad Branch	50 0 0		
Fawley Branch	50 0 0		
Birmingham Section	20 0 0		
	390 0 0		
Unallocated	110 0 0		
	500 0 0		
„ Sundries :—			
Library Expenses	76 11 9		
Subscriptions to Societies	67 14 3		
Scholarship Awards	100 0 0		
Depreciation of Furniture (10%)	131 10 7		
Cost of Oil Shale Conference	795 11 0		
		1171 7 7	*608*
„ Publications Revenue Account—Deficit for year		2353 6 11	—
„ Balance being surplus Revenue for year		2782 19 9	*3083*
		£17,418 5 4	*£16,630*

OF PETROLEUM

YEAR ENDED DECEMBER 31, 1950

	£	s.	d.	1949 £
By Members' Subscriptions received for 1950	8171	3	6	6291
„ Members' Subscriptions in Arrear, received during year	99	4	6	361
„ Member-Company Subscriptions received for 1950	8361	17	6	7368
„ Special Subscription	20	0	0	20
„ Publications Revenue Account—Surplus for year		—		2250
„ Interest and Dividends received (Gross)	357	7	6	322
„ Repayment of Income Tax deducted from interest on Investments in previous years	123	9	2	—
„ Provision for Income Tax payable no longer required	85	3	2	—
„ Amounts recoverable from Branches		—		18
„ Share of surplus from sale of Publication resulting from Joint Conference with Institute of Fuel	200	0	0	—
	£17,418	5	4	£16,630

PUBLICATIONS

Revenue Account for the Year ended December 31, 1950

	£	s.	d.		£	s.	d.
To Stock in hand at January 1, 1950	1568	5	0	By Advertising	4344	6	11
„ Dispatch Expenses	547	6	10	„ Journal	2695	17	5
„ Journal	5536	15	1	„ I.P. Review	237	11	6
„ I.P. Review	1404	7	9	„ Standard Methods	1060	16	7
„ Abstracts	386	6	6	„ Reviews of Petroleum Technology	890	4	9
„ Standard Methods	21	12	10	„ Electrical Code	26	16	0
„ Modern Petroleum Technology	51	7	10	„ Profit on Exchange	42	11	10
„ Reviews of Petroleum Technology	908	0	9	„ Other Publications	1336	12	4
„ Electrical Code	590	8	4	„ Stock in hand at December 31, 1950	1698	2	10
„ Other Publications	83	0	0		12,333	0	2
„ Publicity	65	19	4				
„ Salaries, National Insurance, and Pension Scheme Contributions	2768	9	1	„ Balance—being Deficit for year carried to Revenue Account	2,353	6	11
„ Proportion of Establishment Expenses	743	10	3				
„ Bad Debts written off	10	17	6				
	£14,686	7	1		£14,686	7	1

CADMAN MEMORIAL FUND

Income and Expenditure Account for the Year ended December 31, 1950

	£	s.	d.	£	s.	d.		£	s.	d.
To Balance at December 31, 1950 :—							By Balance at December 31, 1949	3107	15	7
Cash at Bank on Current Account	459	13	7				„ Interest received gross	81	18	0
£2730 3% Savings Bonds 1965/75 (Market Value at December 31, 1950, £2628)	2730	0	0							
				3189	13	7				
				£3189	13	7		£3189	13	7

We have examined the above Income and Expenditure Account with the books and vouchers of the Fund and find it to be in accordance therewith. We have verified the cash at Bank and have accepted a Certificate from the Institute's Bankers for the Securities held by them on behalf of the Fund.

116, Old Broad Street,
London, E.C. 2.
April 6, 1951.

Grahams, Rintoul, Hay, Bell, & Co.
Chartered Accountants.
Auditors.

HYDROCARBON RESEARCH GROUP

Revenue Account for the Year ended December 31, 1950

	£ s. d.	£ s. d.		£ s. d.
To Grants :—			**By Voluntary Contributions from Members of the Group in respect of 1950**	7000 0 0
King's College	200 0 0		„ **Balance, being deficit for year**	3378 12 2
University of Oxford	2300 0 0			
University of Birmingham	1688 18 10			
Bedford College	1425 0 0			
Queen Mary College	2047 10 7			
University of Liverpool	250 0 0			
University of Cambridge	1456 11 3			
		9368 0 8		
„ **Honoraria**		682 10 0		
„ **General Expenses**		53 1 6		
„ **Wages**		275 0 0		
		£10,378 12 2		£10,378 12 2

Statement of Funds at December 31, 1950

	£ s. d.	£ s. d.		£ s. d.	£ s. d.
Contributions received in advance	5000 0 0		**Contribution due, not yet received**		1000 0 0
Sundry Creditor—The Institute of Petroleum	275 0 0		**Cash at Bank on Current Account**		2116 5 5
			Revenue Account :—		
			Deficit for year	3378 12 2	
			Deduct : Balance at credit at December 31, 1949	1219 17 7	
					2158 14 7
	£5275 0 0				£5275 0 0

We have examined the above Revenue Account and Statement of Funds with the books and vouchers of the Group and find them to be in accordance therewith. We have verified the cash at Bank.

116, Old Broad Street,
London, E.C. 2.
April 6, 1951.

Grahams, Rintoul, Hay, Bell, & Co.
Chartered Accountants.
Auditors.

CARCINOGENICITY RESEARCH FUND

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED DECEMBER 31, 1950

	£	s.	d.		£	s.	d.
To Balance at December 31, 1950, represented by Cash at Westminster Bank, Limited .	2000	0	0	By Cash received from the Petroleum Board (during 1947) on account of research at University of Birmingham . . .	2000	0	0
	£2000	0	0		£2000	0	0

We have examined the above Income and Expenditure Account with the books and vouchers of the Fund and find it to be in accordance therewith. We have verified the cash at Bank.

116, OLD BROAD STREET,
LONDON, E.C.2.
April 6, 1951

GRAHAMS, RINTOUL, HAY, BELL, & Co.
Chartered Accountants.
Auditors.

BENEVOLENT FUND

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED DECEMBER 31, 1950

	£	s.	d.	£	s.	d.	*1949* £		£	s.	d.	*1949* £
To Grant paid . . .				50	0	0	*50*	By Balance at December 31, 1949 .	2740	12	2	*2643*
„ Balance at December 31, 1950 . . .				2829	4	2	*2741*	„ Subscriptions and Donations received during year . . .	83	7	0	*93*
Represented by :—								„ Interest received gross . . .	55	5	0	*55*
Cash at Bank on Current Account .	729	4	2									
£550 3% Defence Bonds * . . .	550	0	0									
£1550 2½% Defence Bonds * . . .	1550	0	0									
	£2829	4	2	£2879	4	2	*£2791*		£2879	4	2	*£2791*

* (Market Value at December 31, 1950, £2100)

We have examined the above Income and Expenditure Account with the books and vouchers of the Fund and find it to be in accordance therewith. We have verified the cash at Bank and have accepted a Certificate from the Institute's Bankers for the Securities held by them on behalf of the Fund.

116, OLD BROAD STREET,
LONDON, E.C. 2.
April 6, 1951.

GRAHAMS, RINTOUL, HAY, BELL, & Co.
Chartered Accountants.
Auditors.

THE INSTITUTE OF PETROLEUM

THIRTY-EIGHTH ANNUAL GENERAL MEETING

THE Thirty-eighth Annual General Meeting of the Institute of Petroleum was held at Manson House, 26 Portland Place, London, W.1. at 6 p.m. on Thursday, April 26, 1951. The President, Mr C. A. P. Southwell, M.C., B.Sc., presided.

The notice convening the meeting was read by the General Secretary (D. A. Hough), and the minutes of the 37th Annual General Meeting were read, confirmed, and signed by the President.

OFFICERS FOR THE SESSION 1951–52

President

MR H. C. TETT: We have been even more than usually fortunate in having Mr Southwell as our President for the past year. (*Hear, hear!*) It is a very great compliment to the Institute that a man in Mr Southwell's position in the industry in these troublous times can find it possible to devote so much of his time and energies to the affairs of the Institute. The Council, particularly, are deeply aware of the great debt that the Institute owes to him for all that he has done, and it gives me very great pleasure to propose to you that we re-elect Mr Southwell as our President for the ensuing twelve months.

MR G. H. COXON: The Institute is exceedingly fortunate in having a man with Mr Southwell's wide experience of the industry as its President, and it gives me very great pleasure to second the resolution.

The resolution was put to the Meeting and carried with acclamation.

THE PRESIDENT: Mr Tett, Mr Coxon, and gentlemen, I wish to thank you for the honour you have done me in electing me as your President again for the second year. It is not an easy bed to lie on, as you know, because most of us who are doing executive work find it difficult to fit in all the work that has to be done to ensure that the Institute is the success it should be, representing our very virile and ever-growing industry. I should, therefore, like on this occasion to express my gratitude and appreciation to those past Presidents and Vice-Presidents and Members of Council who have, at the last minute stepped into the breach when I have not been able to fulfil an engagement.

I should like to express my thanks to you for the honour that you have done me, and to tell you that within my capacity I will do all I can to further the objectives of the Institute during the forthcoming year.

Vice-President

Dr E. B. Evans was nominated by the Council as a Vice-President, and on the motion of the President was elected unanimously.

Members of Council

The following nominations for the four vacancies of the Council were submitted and approved unanimously :

W. S. Ault	E. J. Sturgess
D. L. Samuel	O. F. Thompson

Honorary Treasurer

MR E. A. EVANS : It is my pleasure to propose that Mr G. H. Coxon should be our Honorary Treasurer for the Session 1951–52. Mr Coxon served the Institute for many years as Chairman of the Finance Committee before he was appointed Honorary Treasurer.

MR G. H. THORNLEY seconded the proposal, which was carried with acclamation.

Honorary Secretary

MR H. HYAMS : I should like to propose Mr C. Chilvers as our Honorary Secretary for the ensuing year and on behalf of the Institute, to pay this tribute to him for his past services. As those on Council know, his sterling worth, the admirable atmosphere that exists among the Institute staff, and the close liaison between the staff and the Council are all matters for which we are extremely grateful to him. We must regard ourselves as fortunate in that Mr Chilvers is allowing himself to go forward for election as Honorary Secretary of the Institute for another year.

The motion was seconded by Mr N. E. F. HITCHCOCK and carried with acclamation.

Ex-Officio Members of Council

THE PRESIDENT announced that the following had been nominated as ex-officio Members to represent the Branches :—

H. H. Ballard	*Northern Branch*
J. C. Cragg	*Stanlow Branch*
N. E. F. Hitchcock	*London Branch*
E. J. Horley	*South Wales Branch*
I. McCallum	*Fawley Branch*
W. M. Stirling	*Scottish Branch*

The nominations were accepted unanimously.

MEMBERS ELECTED OR TRANSFERRED

The lists of Honorary Members, Honorary Fellows, Members, Fellows, Associate Members, Associate Fellows, Students, and Member-Companies elected or transferred during the year 1950 were presented and tabled.

REPORT OF COUNCIL AND ACCOUNTS, 1950

THE PRESIDENT : I should like, if I might, to say a few words on this occasion concerning the work of the Institute during the past year.

The membership of the Institute at December 31, 1950, totalled 2539 and the company membership 166. I feel, as I have said in the introduction to the Institute brochure, that in order to ensure that the Institute of

Petroleum provides a real service to our expanding industry, its membership should be fully representative of the industry. I hope that it will be possible to improve the position considerably during the next session. If the Institute fulfils its purpose properly and provides for the needs of its members and the industry, there should be no difficulty in reaching a much higher total membership.

I am glad to record that the attendance at the General Meetings during 1950 showed a very great improvement on 1949. I am sure that if the addresses and papers are of a high calibre, and we get experts on various phases of the industry to give those papers, we can fill the lecture hall at every General Meeting.

I was away in America in May and June of last year and missed a number of Institute meetings, but on my return I went to Glasgow for the Second Oil Shale and Cannel Coal Conference. This was extremely well organized by the Scottish Branch of the Institute under the Chairmanship of Mr Robert Crichton, and it was most successful. The Lord Provost, who entertained delegates to the Conference at an official function in the City Hall, expressed his great pleasure at the opportunity given to him to welcome to Glasgow men from so many countries who had been gathered together at this Conference. I would like it recorded as a well-done, important, and most interesting piece of work which the Institute carried out during the year. I have already written to Mr Crichton, but I would like to take this opportunity of thanking the Scottish Branch for the work that they have done.

The representation of the Institute on other bodies in which we are interested is a matter to which the Council is paying particular attention at the present time. It is important that the Institute should have the best possible outside representation and that it should ensure that every body or association which deals with petroleum or allied affairs has an Institute representative on it.

During my year of office I have taken the opportunity of visiting all the branches in Great Britain, and I have been very gratified by the well-attended meetings and at the interest which everyone has displayed. It is difficult to spare the time to visit branches as far afield as Edinburgh and Swansea, and I hope that all Members of Council will be able to give some service to the industry in this connexion and to read papers and stimulate discussions in our branches. If the load is spread, that of the willing horses will be eased. In this connexion I think we can do more by ensuring that invitations are sent to British and American experts who are visiting this country from overseas, asking them if they will give talks on their particular subjects either to the Institute in London or to the branches.

I am glad to report that a new overseas branch of the Institute is in the process of formation in the State of Kuwait, where there are forty or so members.

The publications side, under the able direction of the Honorary Editor, Professor Garner, is maintaining its high standard, and provides a most creditable output of published matter for such a small staff. I hope that we shall be able to get up-to-date with our annual reviews of petroleum technology, as when this is done there will be little doubt that every copy will be sold.

On the research side, the Council has given close attention to the extension of the activities of the Hydrocarbon Research Group. We are encouraging individual research projects which later on might be considered as a suitable activity for the Hydrocarbon Research Group.

On standardization we have a major task. I believe there are seventy-three committees, and we are considering how co-operation with our American friends in this important matter can best be achieved.

Now there are one or two matters that I would like just to mention, as I feel that at an Annual General Meeting we could discuss what we should do in the future and how we can better what we are doing. One of the important matters is that we ought to have better representation of every phase of the industry in the Institute. If one goes back to the 1913–14 years, the institute was a very small group of experts; for about twenty-five years it gradually grew, but in 1938 it was changed to the Institute of Petroleum and at that time we deliberately widened our sphere to take in people who were not necessarily technicians or scientists. Immediately following the war we did not have the opportunity to develop as we would wish, and I would like to see some system of subdivisions considered, so that we have a panel, for want of a better name, covering each phase and including men who are well recognized as experts in that particular branch of the industy. I refer to geophysical activities, geological, specialist petroleum engineering, oilfield production, drilling, chemical engineering, refinery and petroleum chemical activities, economics, education, and human relations within the industry.

If a method can be worked out to achieve this end, the next step should be to ensure that each of these subdivisions of our industry is represented on Council. It is, I feel, only in some such way that really adequate representation can be obtained in the future. If this is done, I foresee little difficulty in being able to arrange our programme so that members in every division of the industry are catered for by way of papers and published material.

I have been most pleased during my year of office at the expressions of good wishes and offers of assistance which have been given me by leaders of our industry, all of them anxious to see that the Institute is both representative and fulfils a really useful purpose in the industry. With this backing I see no reason why we should not be able to tackle some of these problems for which the Institute is obviously suited. I propose to give some thought to this during the next few months and to put some suggestions to Council in the autumn.

This is a suitable occasion to review the history of the Institute and to take stock. It started, in 1913, with the intention of gathering together men employed in the technical and scientific side of the industry with the main objective then of ensuring a high standard of professional conduct and at the same time of permitting discussion and disseminating knowledge. For the next twenty-five years normal development took place, but, as I have said, in 1938 it was decided to widen the scope of the Institute so that men who were not professional scientists or technicians could join in our deliberations. This development, coming immediately before the war, has suffered in the long war period. In this connexion there is a factor of considerable importance at the present time. I refer to the personal

economic factor. The cost of living and taxation are causing every man to examine very carefully his own personal budget. Consideration of the cost of our annual subscription and of attending evening meetings when so many of our Members have to travel some distance to London, is having an effect on our affairs. It is most desirable and very much in the interests of the young men engaged in our industry that they should join the Institute and that it should give them full value. I have no doubt that this economic problem is one which is affecting all scientific and technological societies and institutions. It may be that we should all co-operate and discuss this difficulty to see if there is any possible solution whereby this financial aspect might be eased in view of the importance of such organizations to the country.

We all know that our industry, under a healthy competitive system, aims at supplying the needs of the consumer with the highest-quality products at the lowest cost wherever they are required, but the achievement of this covers many problems from exploration under tough and arduous conditions through the great variety of chemical engineering and scientific research. So day by day the industry becomes more specialized. We would do well to consider what a great difference there is for the young man going into the industry to-day from the early years of the life of the Institute. Thirty years ago the average man in the industry was a jack-of-all trades, with the result that the senior men in the industry to-day having grown up with modern developments, have a much wider knowledge of the problems. In view of this it is all the more necessary that we should cover all phases of the industry and that the younger men in one branch of its activities should be given the opportunity of widening their knowledge of other spheres by being able to hear these discussed by experts in that particular line.

Another matter to which the Institute should direct its attention is the public's lack of knowledge of the industry and want of understanding of the problems which face our industry. I feel that it may be possible for the Institute to give some service in this direction, as its nature and organization make it representative of the industry as a whole.

In closing I wish again to express my appreciation of the confidence placed in me in my election as President for the next Institute year. Amongst past Presidents of the Institute there have been men of great industry, experience, and capacity, leaders in world-wide development of petroleum, and it is my desire to maintain, within my capacity, the high standard of representation to which our important industry is entitled.

Accounts

Mr G. H. Coxon: During this past year we have been able to increase our capital investments by some £700, and they are now standing in the books at £7400, which is quite a healthy figure. On the revenue side we have to-day about £5000 as compared with £2400 last year. There are certain liabilities to the extent of about £3000 as compared with £1600 last year, but the final position is that the cash in hand on the revenue account is £7800 as compared with £6300.

The Council and especially the Finance Committee are to be congratulated on the way these finances have been built up. This has not just

happened by itself; the Finance Committee, under the able leadership of Mr Hyams, saw the need arising three or four years ago, and recommended that we should start a company-membership campaign. I should like to thank them very much for looking ahead.

MR W. S. AULT: Before formally moving the adoption of the Annual Report and the Accounts I am sure it would be the wish of the Meeting to express to the President and the Honorary Treasurer our appreciation of the extremely clear and yet concise summaries which they have given of the work and the position of the Institute and the position of its finances at the end of 1950. I would also like to express your appreciation to the Honorary Secretary and the Honorary Treasurer for the work which they have put into the task of setting out the Report and the Accounts in such a clear and intelligible manner.

I therefore have much pleasure in formally proposing the adoption of the Annual Report and the Accounts as set before us.

The proposal was seconded by MR J. C. CRAGG and carried unanimously.

APPOINTMENT OF AUDITORS

MR G. H. COXON: I have very much pleasure in proposing that our auditors, Messrs. Grahams, Rintoul, Hay, Bell & Co. be appointed auditors for the coming year at a fee to be agreed by the Council.

MR H. HYAMS seconded the motion, which was carried unanimously.

OTHER BUSINESS

THE PRESIDENT: I feel that we should send our congratulations to Messrs Hill and Taylor, who won the scholarships. I should like also to mention the Cadman Memorial Lecture, which is being given by Dr R. E. Wilson on June 21 at the Royal Institution. In conclusion, I should like you all to know that I have had many promises of support for the Institute from senior executives of the many companies that form our Member-Companies.

Before closing the Meeting I should like to take this opportunity on your behalf of expressing our appreciation of the work which Mr D. A. Hough, our General Secretary, Mr George Sell, Mr Peter Kerr, and the staff have carried out for us during the past year, and I would be glad if you would show your appreciation in the usual way.

The resolution was carried with acclamation.

Now if anybody has any suggestions which they would like to make at this time as to how the Institute affairs can be bettered during the coming year, I will allow a few minutes for that purpose. I think this is a very suitable opportunity to make such suggestions, although, of course, we have not a large number of Members present.

MR COXON: It is a very great credit to you, Mr President, that everybody is so happy with what you are doing.

MR E. C. MASTERSON: During your Presidential address last year I remember you referred to taking advantage of the presence in this country, occasionally of Members from America or a man from the fields—Persia or any of the other fields—who might be in London, in order to ask them to give us an address at one of our meetings, but we have not had anything

like that during this last year, and I was wondering whether it would be possible, perhaps, in the coming year to do something along those lines. I thought at the time that it was an exceedingly good suggestion, if only it could be implemented.

THE PRESIDENT: It is being implemented, but it is extremely difficult to catch these gentlemen who drop in from the skies into London. They never know when they are coming and they never know when they are going. I do not want to steal any of the thunder of the Committee dealing with this, but we have actually on the programme for next year a very well-known American oil economist, Dr Pogue, who will be over here on a visit, and who has promised to give us an address, and also Dr Muskat, the well-known petroleum engineer and physicist. It is not very easy to arrange these meetings. The General Secretary does not always know of their presence in London, but I can assure you we are doing our best to see that we catch them. Of course, the men from the fields are mostly here in the summer, during our "close season," but that is a matter upon which the Institute is also trying to do its best.

If there are no other suggestions at the moment I can only say that I am sure Mr Hough will be very pleased to receive suggestions in writing for consideration during the year, and I will now declare the Annual General Meeting closed.

The proceedings then terminated.

OBITUARIES

WILLIAM BRUCE DICK

WILLIAM BRUCE DICK was a Founder Member of the Institute. The industry which he entered in 1880 was then very different from what it has since become. Through its many changes, however, he himself remained unchanged in those qualities which endeared him to all. His integrity and courtesy were outstanding, even in those more spacious days when these qualities were less rare.

He was the first president of the National Lubricating Oil & Grease Federation, and during the first world war was Chairman of the Mineral Oil Allocations Committee, which acted in an advisory capacity to His Majesty's Government on the importation of petroleum products into the U.K.

In his early days he was with Dick, Kerr & Co. Ltd., a company founded by his father, and which is now one of the constituent companies of The English Electric Co. Ltd.

Education in Germany and France gave him that mastery of those languages to which all, knowing his faultless diction, paid tribute.

A great lover of the arts, William Bruce Dick was for many years a leading member of the famous Strolling Players' Amateur Dramatic Society, well known for its many fine West End productions in the cause of charity. In addition, he was a most accomplished pianist.

Sport also played a considerable part in his life. He rowed for London Rowing Club in the Grand Challenge Crew at Henley in 1888, and won the London Cup for Sculling at the Metropolitan Regatta. At golf also he was above the average, although not so outstanding as his famous brother.

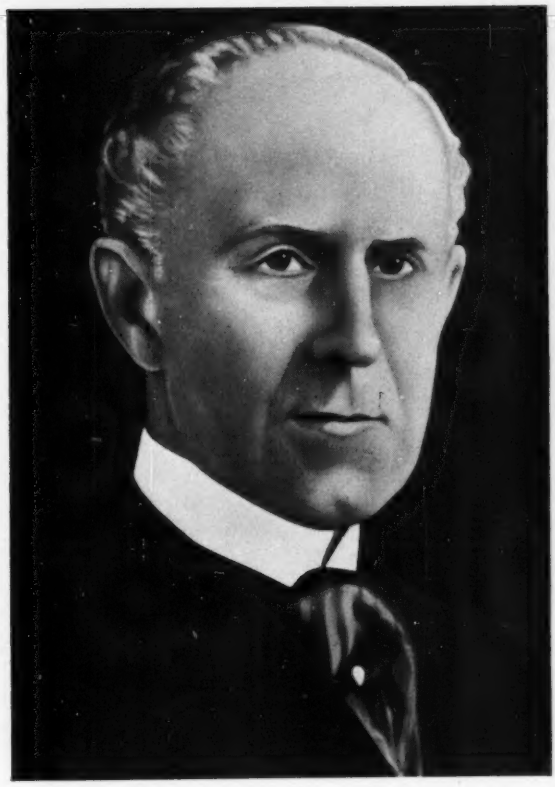
He was indeed a man and a very gentle soul, and to have known him was a privilege.

A. J. SEAR

REGINALD AUBREY CARDER

ON Saturday April 14, having completed a normal week's work, Mr R. A. Carder, chairman of the Esso Petroleum Company Ltd., went into hospital. A fortnight later, on April 28, he died. Only his immediate circle of colleagues knew of his illness, and even they were hardly aware of its gravity. That was typical of a man who always believed in shouldering his own burdens.

Born in Worcestershire, he spent much of his early life in the Midlands, particularly in Birmingham, where he was educated and started his business career. His was the generation of young men who were swallowed up in the first world war. He was twenty-two when it broke out. He was commissioned in the Royal Naval Division, and served with distinction



WILLIAM BRUCE DICK

[*To face p.* 344.

REGINALD AUBREY CARDER

in the Middle East and France before being seconded to the Petroleum Executive, headed at the time by Sir John Cadman (the late Lord Cadman). Twenty-five years later he was to be a Director of the Petroleum Board, the similar body set up to administer Britain's petroleum supplies during the second world war.

In 1920 Mr Carder joined the Anglo-American Oil Company as an assistant to the company secretary. By 1925 he was deputy secretary, and five years later succeeded to the secretaryship. Finance, all along, was his forte. Rapid promotion was soon awaiting him. In 1933 he was elected to the Board of Directors. In 1940 he was appointed managing director. To have reached that position after barely twenty years' service, which had begun before he was thirty, is evidence enough of the regard in which his character and abilities were held.

It was during his period of office as managing director, and his subsequent period as chairman from 1949 up to the time of his death, that Mr Carder made his most significant contribution to the company's development, and indeed to the country at large—for his managing directorship coincided with his directorship of the wartime Petroleum Board. He shared in the planning of that Board months before the actual outbreak of war, and so precisely was it planned that on Monday September 4, 1939, it went into immediate action. Throughout the war Mr Carder contributed to the Board that same zeal and energy which always characterized his career with the company.

With the end of the war the company once again had his undivided attention. Soon in addition to the considerable problems of the company's return to peace-time trading, it was largely concentrated on the complex financial preliminaries to the building of the new Esso refinery at Fawley. Fawley is his visible memorial. To all the extended negotiations—in this country largely with Government Departments, and in the United States with the parent company—Mr Carder brought his wisdom and foresight to bear. Presently, as the refinery began to take shape, he would slip away to Fawley when he could be spared from London, and down there they will tell you that no visitor took a more personal—and practical—interest in the progress of the work. Unannounced, he would walk round the site, talking to the men who were so dramatically bringing his plans and financial calculations to reality. Of that reality he was at least assured; but it is indeed sad that he did not live to see the enterprise completed.

Recently, Mr Carder was closely associated with two most important contributions to the national economy as well as to the petroleum industry generally. One was the successful, though lengthy, negotiations which led to the end of petrol rationing in Britain in May 1950. The other was the satisfactory agreement concluded in February of this year between H.M. Government and the Standard Oil Company concerning dollar/sterling oil problems. In these exchanges—as well as the unceasing conferences and talks necessary in conducting the affairs of Fawley—there was opportunity for furthering a desire very close to Mr Carder's heart, the strengthening of Anglo-American ties and friendship. Whenever he made a public appearance, or in the ordinary run of business, he frequently stressed this, not as a matter of mere commercial advantage, but of sound—and, in fact, indispensable—international policy.

On May 8 a Memorial Service was held at St Margaret's, Westminster. In addition to Mrs Carder and her family, it was attended by more than 400 member of the Esso Petroleum Company and its affiliates, and by representatives from numerous other companies and commercial organizations. The Institute of Petroleum, of which Mr Carder had been a Fellow since 1945, was represented by the General Secretary.

S. A. R.

ABSTRACTS

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Oilfield Exploration and Exploitation

Geology

1362. Paleozoic stratigraphy of part of northwestern Arizona. A. H. McNair. *Bull. Amer. Ass. Petrol. Geol.*, **35** (3), 503–41.—The area covered in this study extends approx 180 miles along the boundary between the Colorado Plateau and the Great Basin from southeastern Nevada to north-central Arizona. The Grand Canyon crosses the central part of the area at right angles, and the prominent Grand Wash, Hurricane, and Aubrey Cliffs lie approx parallel with the line of sections studied.

The southwestern margin of the Colorado Plateau is approx perpendicular to the axis of a persistent Paleozoic sedimentary basin which had its maximum sedimentation in central Nevada. The purpose of this study was to describe the stratigraphic relationships along the margin of the plateau to Jerome, Arizona, where a relatively thin and incomplete section is found.

Eleven stratigraphic sections were measured along the southwestern margin of the Colorado Plateau, from north-central Arizona to southeastern Nevada. The northwestern sections are thick and consist dominantly of limestones. The southeastern sections are thin and contain much clastic material.

The author describes each of these stratigraphic sections in some detail. E. N. T.

1363. The Mississippian–Pennsylvanian unconformity in southern Illinois. R. Siever. *Bull. Amer. Ass. Petrol. Geol.*, **35** (3), 542–81.—The unconformity between the Mississippian and Pennsylvanian systems is well below ground level throughout the area

covered by this paper. Thus only subsurface geologic methods could be used in mapping the unconformity. There are many published descriptions of the unconformity for areas where the Mississippian–Pennsylvanian contact is exposed; in fact, almost every areal geology report covering such areas in southern Illinois, southern Indiana, and western Kentucky includes some discussion of the erosional surface, but there has been no integrated regional study of the outcrops and no detailed study of the unconformity in the subsurface. Field work in the southern part of the Eastern Interior basin has been helpful to the writer in interpreting the subsurface data.

The geologic history of the unconformity started with uplift and withdrawal of the sea in late Chester time followed by a long period of sub-aerial erosion. A peneplain was formed across bevelled minor structures and older Chester and Lower Mississippian formations at the structurally higher basin borders. After peneplanation and a subsequent second uplift a new cycle of erosion began that resulted in the incision of deep channels in the peneplain surface. In early Pennsylvanian time the topography was buried by detritus laid down by aggrading streams, which latter merged with coarse sediment advancing westward from the Appalachian geosyncline. During and after Pennsylvanian time the unconformity was warped, folded, and faulted to its present attitude.

Several isopach maps indicate the configuration of the channel systems and the upland surface between channels. E. N. T.

1364. Types of oil and gas traps in southern Oklahoma. E. L. Selk. *Bull. Amer. Ass. Petrol. Geol.*, **35** (3), 582–626.—The important oil and gas pools of southern Oklahoma are found in reservoirs which were closed as the result of geological processes accompanying two major orogenies. Minor disturbances, which occurred at various times during and after these periods, had little effect on the distribution of the important producing areas. The geological processes resulting from the two diastrophic movements provided a variety of reservoir traps including folds, faults, truncation, and onlap and overlap of beds. Although this multiplicity of traps should have been apparent, the extent of exploration until late in 1944 was confined to the search for oil primarily in closed anticlinal structures.

The oil and gas accumulations in the oilfields of southern Oklahoma are principally associated with the structure and stratigraphy resulting from two major orogenic movements in Pennsylvanian time, and minor movements in Permian and post-Permian time.

The vagaries of entrapment of hydrocarbons in the various geological horizons are manifest in subsurface maps and cross-sections of the developed oilfields. A review of several of these fields in this perspective reveals the types of oil and gas traps generally found in southern Oklahoma, which may serve as a guide in developing ideas for future exploration in this and other provinces. E. N. T.

1365. The new reef fields in Texas. C. H. Keplinger and J. M. Wanenmacher. *World Oil*, Sept. 1950, **131** (4), 181–8.—The history, development, and reserves of these fields are discussed. A. H.

Geophysics and Geochemical Prospecting

1366. The first geochemical (soil) analysis. T. Szura and F. Klewski. *Nafta*, Dec. 1949, **5**, 342–7.—Depth and surface determinations show the influence of hydrocarbon deposits on layers above it and on the soil. Information is gained from cores by distillation, S.G. determination and extraction (for hydrocarbons), by titration and displacement (for acid radicals Cl' and CO_3'') and by luminiscence (for heavy hydrocarbons). Porosity, permeability, and grain size are also found.

Surface determinations were started in Autumn 1949 and the methods are still being improved. Field work is of regional and local nature. Samples of soil, water, or gas are taken from a depth of about 2 metres. Wells are immediately sealed up. Hydrocarbons are burnt and CO_2 is absorbed in $Ba(OH)_2$ solution. Time taken for deposition of $BaCO_3$ crystals is a measure of concentration of CO_2. By absorption of all hydrocarbons except CH_4 and repetition of this experiment $\%CH_4$ is found. Sensitivity of this method is about 10^{-4} % CO_2.

Results of local determinations combined on regional scale confirm or deny the existence of deposits deeper underground. M. S.

Drilling

1367. Collapsible oil well buildings. S. Krimmer. *Nafta*, Dec. 1949, **5**, 350–4.—The Drilling Sub-committee of the Polish Petroleum Commission has issued instructions for such buildings and approved some projects. Plans and views are included in the paper. Given is a list of materials and complete costs of erection as well as demolitions. Time of erection 20 to 25 days. Time of demolition 10 to 15 days. M. S.

Production

1368. Core analysis technique for limestone and dolomite. L. C. Locke and J. E. Bliss. *World Oil*, Sept. 1950, **131** (4), 204–7.—Measurements of porosity in limestones and dolomites are quite different from similar measurements in a homogeneous sand. It is shown that limestones and dolomites are not homogeneous as regards porosity, and therefore it is impossible to select a plug sample. A new method has been developed whereby the entire core is analysed as a whole for permeability and porosity. The cores are cut into convenient lengths up to 2 ft. After extracting oil and water and drying, the cores are subjected to a high vacuum. The vacuum is released and fluid is allowed to enter, the volume of fluid being measured against time. Pressure up to 1000 p.s.i. is supplied, and the volume of fluid entering for each increment of pressure is recorded. Permeabilities so calculated are non-directional, since fluid enters from all sides, these, however, check very closely with measured P.I. data on wells where such data are available. A. H.

1369. Gas lifting deep wells in the Permian basin. W. P. Massey. *World Oil*, Sept. 1950, **131** (4), 190–6.—Gas-lift operations and installation calculations are discussed. Charts are given for determining pressure due to a column of gas, determining opening pressure for flow valve at various temperatures, showing average flowing gradient, flowing fluid gradient, etc., which are averages determined over a number of wells. Corrosion problems are discussed. A. H.

1370. Gas lift: principles and practice, Part 3. C. D. Fletcher. *World Oil*, Sept. 1950, **131** (4), 217–22.—Wells having a very low fluid level and low productivity, where the bottom-hole pressure is insufficient to feed to a height for a closed type of installation, are usually produced with an accumulation-chamber installation. There are several variations of this type of installation, and these are described with the help of sketches. Dual-completion installations are also illustrated, but as there are so many variations of this type it is advised that a competent gas-lift engineer be consulted when this problem is encountered. A. H.

1371. Field and laboratory studies of methods of conditioning water for subsurface injection. J. W. Watkins, C. E. Arthus, and F. R. Willet, Jr. *Oil Gas J.*, 17.8.50, **49** (15), 120.—Use of unconditioned water for injection projects may lead to corrosion of well equipment and plugging of formations. Water-conditioning systems may be of the closed or open types. With the closed systems formation waters or waters not containing constituents likely to cause plugging or corrosion are circulated, contact with air at all points being avoided. With open systems the water is aerated and chemically treated to remove undesirable constituents. When organic matter is present bactericides or algæcides are used with both systems. Corrosion inhibitors may also be added.

A recent study of water-conditioning plants involved corrosion tests and chemical analyses. Corrosion tests were based on the loss of weight of a 2-inch dia steel disc, contained in a glass jar through which water is conducted at controlled velocity and observed temp for 72 hr. Chemical analyses were made for dissolved oxygen, free carbon dioxide, hydrogen sulphide, pH value, total and dissolved iron, alkalinity to phenolphthalein and methyl orange as calcium carbonate, residual chlorine, and turbidity. Hardness as calcium carbonate and total chlorides were determined for identification purposes. Microscopic examinations were made to determine the types and quantities of organic matter present.

The experimental procedures involved in the corrosion and analytical studies are described. It is concluded that: (1) Complete and accurate analyses of the waters

to be injected and of the interstitial water are necessary before designing and constructing conditioning plant. Effects of possible chemical reactions between constituents of two or more waters should be considered. (2) Determinations of pH value, alkalinity and carbonate stability, dissolved oxygen, and free carbon dioxide and hydrogen sulphide should be made daily. Total and dissolved iron should be determined at regular intervals. Increase in the iron content between injection and producing wells is particularly important. (3) Sedimentation tanks to give long detention time and maximum possible sedimentation. (4) Effect of organic matter in plugging pore spaces should not be under-estimated. (5) Closed systems may be used with waters containing negligible acid gas and low iron and suspended solids contents. (6) It is desirable to develop methods of water conditioning other than those in general use.

References appended. R. W. G.

1372. Interpretation of the measurements obtained using the "I.N. type spinning wheel." W. Paraszczak. *Nafta*, Dec. 1949, **5** 354–8.—Measurements made with the improved I.N. type spinning wheel are that of total depth and liquid level. By making a series of liquid-level measurements at regular intervals productivity of well can be estimated, well-bottom pressure found, and the size of best suited pump chosen. An experimental determination is described together with formulæ used and graphs plotted.

The level of the water–oil interface can be also found after a small adjustment to the I.N. spinning wheel. M. S.

1373. Laboratory apparatus for studying oil recovery efficiency ("artificial deposit"). J. Ostaszewski. *Nafta*, Dec. 1949, **5**, 362–6.—For the needs of technologists an "artificial deposit" apparatus has been constructed and used in Krosno. It consists of a 10-inch pipe packed with sand or rock which is filled with crude, gases, and water under pressure. These are then obtained from this "artificial deposit" under laboratory conditions and supervision. Results are similar to field exploitation on the scale of 1 hr ≡ 1 to 5 years. Several problems were studied and the rock could be inspected after experiments. A sketch, a graph, and a photograph are reproduced. M. S.

1374. High pressure water injection for maintaining reservoir pressures, New Hope field, Franklin County, Texas. A. S. Trube and S. N. De Witt. *Petrol. Tech.*, Nov. 1950, **2** (11), *A.I.M.M.E. Tech. Paper No.* 2939, 325–34.—In the New Hope field, Franklin County, Texas, water injection has been operated in the Bacon Hill and Pittsburg reservoirs at depths of 7300 to 8000 ft. The oil in each of these reservoirs was grossly undersaturated. Production data indicated no apparent water encroachment in the Bacon reservoir before injection began, but the other two reservoirs had some natural water influx, although not enough to maintain pressures above the bubble point. The Bacon and Hill reservoirs responded almost at once to water injection, but no effect was observed in the Pittsburg until August 1948. The Pittsburg is the least permeable reservoir.

The main objective is to increase recovery, but to date there has been a reduction in lifting costs. Channelling has not occurred, although some wells adjacent to injection wells have gone largely to water.

It is believed that the water injection will increase recovery by 70% above that which would have been obtained by dominantly solution-gas drive.

Fresh and salt subsurface waters are injected, using a system which excludes air. Injection pressures up to 4000 p.s.i. have to be used. Plugging occurs with mixing of the waters. G. D. H.

1375. Relative productivity of perforated casing. II. R. A. Howard and M. S. Watson. *Petrol. Tech.*, Nov. 1950, **2** (11), *A.I.M.M.E. Tech. Paper No.* 2933, 323–4.—The normal electrolytic model represents a clean hole through the casing with undisturbed formation beyond. In a new model the platinum electrodes project beyond the lucite cylinder by varying amounts, thus simulating "depth of penetration," *i.e.*, penetration of the formation beyond the cement and casing.

Even 1-inch penetration gave a large increase in relative productivity. As the depth of penetration increases it becomes less and less advantageous to use large

perforation densities, 80% of open-hole productivity being obtained with three 0·5-inch dia holes per foot when the penetration is 4·03 inches. The initial inch of penetration is much more important than an additional inch.

The electrolytic model is equivalent to flow of a single homogeneous incompressible liquid through an isotropic formation. G. D. H.

1376. Micro logging in West Texas and New Mexico. A. Morazzani and W. J. Lytle. *World Oil*, Sept. 1950, **131** (4), 127–30.—The micro log is now recognized as a most useful record for evaluating the productive section of a well, and its use with the Permian basin has become commonplace. In the dolomites or limestones it is difficult, in many cases, to determine the thickness of pays with the spontaneous potential log. With the aid of diagrams and charts the construction and use of the micro log are described. A. H.

1377. The effect on well productivity of formation penetration beyond perforated casing. J. M. McDowell and M. Muskat. *Petrol. Tech.*, Nov. 1950, **2** (11), *A.I.M.M.E. Tech. Paper No.* 2891, 309–12.—The effect on well productivity of formation penetration beyond perforated casing has been studied experimentally by means of an electrolytic analogue. The equipment consisted of a 4-ft-dia cylindrical tank, with copper foil on the vertical wall, and a waxed plywood bottom. Copper sulphate was the electrolyte. A copper rod represented an open hole, while polystyrene tube penetrated by copper wires represented perforated casing. Different amounts of protrusion of the wires were used. Varying degrees of penetration and of perforation density were investigated. It was found that the penetration of the perforations into the surrounding formation may so increase the productivity as to approach or even exceed that for open-hole completions. The gains indicated by penetration or perforation density will be realized only when the cementing of the casing has given a perfect seal. If channels have been left in the cement sheath, even a single-perforation opening into such a channel will give large well capacities which may not be appreciably increased by additional perforations. G. D. H.

1378. The Kobe porosimeter and the Oilwell Research porosimeter. C. M. Beeson. *Petrol. Tech.*, Nov. 1950, **2** (11), *A.I.M.M.E. Tech. Paper No.* 2953, 313–18.—Among other things a Boyle's law porosimeter permits the measurement of all basic properties on the same sample, thereby eliminating the sources of error inherent in the use of adjacent samples.

Investigations of gas absorption on various porous materials show that the use of helium in Boyle's law porosimeters reduces to a negligible amount the error due to absorption or desorption of the working gas.

Two Boyle's law instruments are described which permit accurate and rapid measurements of viscosity. Sketches and explanations are given, along with derivations of equations required in making precise determinations. Summaries of data obtained during calibration are tabulated, and analyses of the data are presented as indications of the accuracy of each device. Comparisons are also made of measurements with each of the instruments on the same test pieces and cores. G. D. H.

1379. Phase equilibria in hydrocarbon-water systems. II. The solubility of ethane in water at pressures to 10,000 p.s.i. O. L. Culberson and J. J. McKetta. *Petrol. Tech.*, Nov. 1950, **2** (11), *A.I.M.M.E. Tech. Paper No.* 2932, 319–22.—A preliminary experiment showed that equilibrium was attained within 1 hr after beginning agitation of the cell.

Solubility determinations for ethane in water were determined at 100°, 160°, 220°, 280°, and 340° F at pressures up to 10,000 p.s.i.a. There was a minimum solubility zone at pressures up to about 9000 p.s.i.a. The temp at which this minimum occurs decreases as the pressure increases. The temp range was insufficient to give solubility maxima at pressures above 300 p.s.i.a.

The data are presented on graphs and in tabular form, and a comparison is made with information on the solubility of natural gas. At 5000 p.s.i.a. the solubility of the latter (88·51% methane, 6·02% ethane) is about twice that of the former.

G. D. H.

1380. Selective acidizing in the Permian basin. J. E. Kastrop. *World Oil*, Sept. 1950, **131** (4), 116–24.—Increased oil and gas production in the Permian basin has been effected by proper application of selective acidizing techniques. The principal methods employed are: (1) The two-pump or casing method. One pump supplies oil to the annulus, or to tubing, depending on whether it is desired to hold acid on the lower or upper sections of the pay zone, while the second pump injects acid through the tubing or annulus. (2) Application of acid to the face of the formation by jetting with the acid jet gun. This method applies primarily to open-hole completions, and is quite effective in removing cement sheaths. (3) Use of packers to isolate one or more zones to be treated. (4) Placing temporary plugs in the bottom of the well to protect the lower section from acid. (5) The spotting of temporary plugging agents, such as mud or jelly seals, over the more-permeable sections in order to build up sufficient pressure to break down the less-permeable sections. (6) Setting temporary bridge plugs. (7) Selective acidizing with the " electric pilot " is a development of (1).

Aids to selective treatment, such as the electric pilot and tubing electrode, are described, and a few case histories are discussed. A. H.

1381. Drill collar preventive maintenance in the Permian basin. J. B. Coulter. *World Oil*, Sept. 1950, **131** (4), 132–41.—The use of multiple drill-collar strings (eighteen to twenty-one collars) has become common in the Permian basin. As the number of collars in a string has increased, however, so has the number of failures. Thus, higher penetration rates are being offset to some extent by costly fishing jobs. The author has been closely connected with the problems of drill-collar manufacture and maintenance for some eleven years. During this time he has inspected innumerable failures. In only a few cases have these been due to workmanship or faulty materials in manufacture. Three main causes are known: pure fatigue, corrosion fatigue, and wobble fatigue. Until more is known about fatigue it is difficult to eliminate this problem. Suggestions for avoiding fishing jobs, however, are given. These include: consultation with manufacturer when selecting drill collars, surface stressing of the thread roots on all new connexions, the use of thread protectors on both pin and box connexions when not in use, periodic inspection for fatigue cracks, the avoidance of wobble at critical speeds by not exceeding the max r.p.m. recommended by the seller and also by ensuring that collars are at all times straight and that threaded connexions are in perfect alignment with the body. For drill collars only, the author recommends the H-90 type of joint and also recommends a smaller size connexion after a collar has worn. A table is given showing the weight in air, in pounds per foot, of drill collars when O.D. and I.D. are known. It is pointed out that in a 9·8 drilling mud, for example, a collar will lose appprox 15% of its weight, and this should be allowed for in calculating drill-collar weight. A. H.

1382. Slaughter field problems increase operating costs. W. D. Powers. *World Oil*, Sept. 1950, **131** (4), 209–14.—Since the discovery well was completed in Oct. 1936, the Slaughter field of West Texas has developed to the extent of 2221 wells producing from 74,250 acres. Corrosion has appeared in many different ways, but has been insignificant as compared with the corrosion attack recently encountered. This has occurred in the casing, with few exceptions, between 500 and 1000 ft. The cause has not been determined positively. Paraffin has caused difficulty in the smaller flow lines. G.O.R. and future outlook are discussed. A. H.

Oilfield Development

1383. Oil and gas developments in New Mexico during 1949. J. M. Kelly and E. E. Kinney. *Petrol. Tech.*, Nov. 1950, **2** (11), 314–20.—New Mexico produced 47,634,539 brl of oil in 1949. 565 wells were completed, 354 giving oil and seventy-four gas. Ninety-two wildcats gave two gas and eleven oil pools. Oil was discovered in the Dakota at Lindrith in the San Juan basin, 90 miles east of the Rattlesnake pool.

The new discoveries and important wildcats are listed. Tables give by fields salient geological and production data. G. D. H.

1384. Oil and gas developments in Oklahoma during 1949. D. L. Becker, C. S. Larkey, J. A. Bermingham, T. Baird, M. B. Penn, R. E. McMillen, and W. M. Edinger. *Petrol. Tech.*, Nov. 1950, **2** (11), 209–65.—49% of all Oklahoma's 1949 wells were drilled in the

southeastern and southwestern districts, and these had 45% of the exploratory wells, 30% of the new oilfields, and 33% of the new gas fields. Among the more important discoveries were South Panther Creek, Northeast Roady, Southeast Bebee, South Palacine, and West Sholem-Alechem. In northern Oklahoma the discoveries included Southeast Keyes, Northwest Hunter, Rich Valley, and East Renfrow.

576 wells were completed in the Seminole area, 295 giving oil and thirty gas. There were eighty wildcats. Twenty new fields were opened. The area produced 18,526,305 brl of oil.

Extensive tabulated data on the fields and on drilling operations are included.

G. D. H.

1385. Oil and gas developments in Pennsylvania during 1949. C. R. Fettke. *Petrol. Tech.*, Nov. 1950, **2** (11), 280–9.—2017 wells were completed in 1949. 430 gave gas, and fifty-three oil; thirty-seven were for gas storage, and 1318 were for secondary recovery operations. Twenty-seven deep wells were drilled, and sixteen found gas.

The 430 new shallow gas wells had an initial total output of 93,405,000 cu. ft/day. The fifty-three wells aggregated 260 b.d. initially. The average daily oil output in 1949 was 31,347 brl. Bradford gave 26,804 b.d. (24,674 b.d. from the Pennsylvanian sector). Pennsylvania's 1949 shallow gas production was 70,000,000,000 cu. ft. Deep sands yielded 350,000,000,000 cu. ft.

Tables summarize the results of shallow sand completions by counties, and give the results of deepening shallow sand wells. Data for the deep-well completions are summarized. The stratigraphic positions of the oil and gas sands are given, and graphs show production, well completions, and oil prices since 1930. The annual rate of deep sand exploration and development is shown since 1930. G. D. H.

1386. Oil and gas developments in South Texas during 1949. G. S. Wilson. *Petrol. Tech.*, Nov. 1950, **2** (11), 266–79.—In 1949 South Texas produced 117,000,000 brl of oil. 1993 wells were completed, 622 being exploratory. 908 development wells gave oil and 172 gas. Eighty-eight wildcats gave oil, and sixty-two gas or condensate. 400 producers were abandoned or shut in indefinitely during 1949. 48% of the 13,800 oil wells were on artificial lift.

Twenty-four new pools were completed in the Frio.

Salient data on the oilfields are tabulated. G. D. H.

1387. Oil and gas developments in Tennessee during 1949. H. C. Milhous. *Petrol. Tech.*, Nov. 1950, **2** (11), 290–2.—Forty-seven tests were drilled in 1949. Eight were successful. The 1949 oil output was 18,000 brl; gas totalled 137,000 cu. ft. The important wildcats are listed, with a note of the result and the deepest zone tested. Oil was discovered in the Nubia and Sugar Grove fields. G. D. H.

1388. Oil and gas developments in West Texas during 1949. L. H. Thawley. *Petrol. Tech.*, Nov. 1950, **2** (11), 293–313.—During 1949 3261 wells were completed in West Texas. There were 2778 oil wells and twenty-four gas wells. 343 wildcats yielded sixty-three oil and six gas wells. The discovery well of the Warfield pool was completed in the Ellenburger at 13,049 to 13,130 ft. Diamond M and Sharon Ridge were two new Scurry County reef finds. Three new Spraberry sand pools were opened. Runnels County had eleven oil discoveries.

228,888,971 brl of oil was produced by 26,040 wells, of which 10,735 were flowing. The cumulative production is 2,736,890,425 brl.

Extensive tables summarize the main data for individual fields, and for 1949 successful and unsuccessful wildcats and extensions. G. D. H.

Transport and Storage

1389. S.S. "British Adventure." Anon. *Petroleum*, Feb. 1951, **14** (2), 43.—A brief description of the 28,000-ton tanker completed for the Anglo-Iranian Oil Co. Ltd. The tanker, of prefabricated construction, will carry a little more than 25,000 tons of crude oil from the Middle East to the refineries at Llandarcy and Grangemouth.

R. E. P.

1390. Preparing for the super-tankers. Anon. *Petroleum*, Feb. 1951, **14** (2), 45–6.—Describes design for the Eastham Oil Dock, Cheshire, and gives details of the first-year progress. Each of the four berths will be able to accommodate one 28,000- or 30,000-tons deadweight tanker. R. E. P.

1391. Slack in buried gas pipelines. G. M. McClure and L. R. Jackson. *Oil Gas J.*, 22.3.51, **49** (46), 86.—Data are given to permit detailed analysis of the role of slack in the performance of a pipeline.

Slack is introduced to handle temp variations occurring before line is covered, and can minimize longitudinal stresses. Slack should be so designed that the pipe has little or no residual stress prior to backfilling; once backfilled, slack will be ineffective in reducing residual stress.

Tables show longitudinal stresses and soil restraints for seventeen tests.

G. A. C.

1392. Laying a difficult pipeline river crossing. P. R. Hammond. *Pipe Line News*, Feb. 1951, **23** (2), 22–5.—The laying of a pipeline across Lake Butte des Morts, near Oskosh, Wisconsin, involved a lake crossing of 3720 ft. In addition, trenches were blasted through 1300 ft of swamp on the south side and 800 ft on the north side, making a total length blasted of 5820 ft. Details of the terrain and river conditions are given, together with full details of equipment used and methods employed. F. M.

1393. Alligheny crossing. Anon. *Pipe Line News*, Feb. 1951, **23** (2), 26–8.—A brief account is given of the Tuscarora pipeline from Bayway, N.J., to Midland, Pa., which is to be rebuilt with double the existing capacity of 25,000 b.d. Originally built to carry crude oil from Mid-Continent to the East Coast the line now serves for distribution of Bayway Refinery products to Pennsylvania. F. M.

1394. Interprovincial pipeline. Anon. *Pipe Line News*, Jan. 1951, **23** (1), 21–9.—An illustrated account of the laying of 1127 miles of pipeline from Edmonton (Alberta) to Superior (Wisconsin). The line is comprised of 450 miles of 20-inch pipe, 340 miles of 16-inch pipe in the Canadian section (Edmonton–Regina–Gretna), and 360 miles of 16-inch pipe in the U.S.A. F. M.

1395. Portland–Montreal new loop line. Anon. *Pipe Line News*, Jan. 1951, **23** (1), 18–20.—Details are given of the new 18-inch oil line between Portland (Maxine) and Montreal. The new line follows the route of the 1941 12-inch line, and both lines are used. Modifications to the pumping stations are described which have resulted in considerable power saving over previous operations. F. M.

1396. Micro-wave radio system. Anon. *Pipe Line News*, Jan. 1951, **23** (1), 33–4.—A brief account is given of the micro-wave radio system between Elk City and Cushing, Okla., operated by the Shell Pipe Line Corp. F. M.

1397. Micro-wave communications for pipeline service. E. B. Dunn. *Pipe Line News*, Nov. 1950, **22** (9), 86–8.—The advantages of micro-wave radio for pipeline communications are discussed, with a description of the 2000 Mc band system used by the Keystone Pipe Line Co. between Philadelphia and Valley Forge. Price details for installations in various terrains are quoted for comparison with telephonic communications. F. M.

1398. Operating costs: diesel (dual fuel) versus electric power costs. C. C. Keane. *Pipe Line News*, Feb. 1951, **23** (2), 17–21.—A comparison of the operating costs of dual-fuel diesel engines and electric-power-driven pumping-stations on comparable loads is illustrated by graphs of power savings and amortization periods for two hypothetical cases. The dual-fuel engine is defined as one which burns gaseous fuels and fuel oil and operates on a full diesel cycle whether burning gas and fuel oil in combination or burning straight diesel fuel. The calculations illustrated enable an estimate of amortization period to be made for various fuel costs and compared with corresponding electrical installations. F. M.

1399. Constructional development of road tankers for delivery of liquid engine fuels in Germany. F. Zachen. *Erdöl u. Kohle*, 1951, **4**, 149–53.—General illustrated description of road-tanker construction and operation. Present German capacity limit for low-flash liquids is 8000 litres (max of any one compartment 6000 litres). Aluminium is main constructional material for tanks, but average German A1 tanker is 7% heavier than U.S. steel vehicle, due to frameless construction and lighter traction unit in latter. Flow meters are usual for measuring output, speed of up to 700 litres/min is attainable. V. B.

1400. Mobile transportation and maintenance equipment. T. L. Opie. *Pipe Line News*, Nov. 1950, **22** (9), 28–30.—Details are given of personnel carriers, maintenance trucks, heavy-duty maintenance trucks, bull-dozers, caterpillar-mounted vehicles, and air patrol units used by the Socony-Vacuum Oil Co. in pipeline maintenance in New York and Pennsylvania. F. M.

1401. Containers for petroleum products and other special materials. J. Mason. *I.P. Review*, Feb. 1951, **5**, 43.—The ideal container must be of suitable size and shape, sufficiently strong and tight as not to be chemically affected by the contents, be weather-resistant and not affected when the contents are discharged, must be in good condition when filled and correctly and adequately labelled. The type and nature depend upon the material to be enclosed. Typical containers for various products are described, and the various difficulties encountered fully discussed. The importance of "air tightness" of small containers is stressed to eliminate troubles due to "breathing." R. H.

1402. Monitoring panel and automatic controls improve tank farm efficiency. G. M. Wilson. *World Oil*, Sept. 1950, **131** (4), 238–40.—The layout and control is described of Shell Pipe Line Corporation's Hendrick tank farm, currently handling 36,000 b.d. of crude. Most valves are remote controlled from a central outdoor control panel. Tanks are connected by a single combustion suction and filling line to eliminate the possibility of an operator making an error. Tanks are gauged from ground level by remote-reading indicators.

It is claimed that with this type of layout station personnel can handle a larger volume of crude with less effort and with less risk of making errors in receiving and shipping. A. H.

1403. Federal Power Commission report. N. L. Smith. *Pipe Line News*, Jan. 1951, **23** (1), 30–2.—Tabulated data on : (*a*) total miles of natural-gas mains at the end of 1949, (*b*) by states, the total miles of natural-gas transmission pipelines, and (c) mileage of natural-gas transmission pipeline construction authorized by Federal Power Commission for facilities involving $700,000 in construction costs Jan. 1 to Nov. 10, 1950. F. M.

1404. Review of gas industry expansion in 1950. Anon. *Pipe Line News*, Jan. 1951, **23** (1), 17.—An abstract of the annual statement of the President of the American Gas Assoc. reviews the expansion of facilities of the gas industry in 1950. F. M.

Refinery Operations

Refineries and Auxiliary Refinery Plant

1405. Blueprint of 1951 refining. Anon. *Oil Gas J.*, 29.3.51, **49** (47), 178.—Thirty-nine flow charts and descriptions of the principal newer petroleum refining processes are given, sectionalized generally under (1) purpose, (2) major equipment used, (3) charging stocks, (4) products, and (5) operating essentials. G. A. C.

1406. Europe's largest refinery scheduled for initial operation within a year. G. Weber. *Oil Gas J.*, 22.3.51, **49** (46), 82.—The 128,000-b.d. crude oil refinery being built at Fawley, England, for the Esso Petroleum Co. is described.

Completed refinery will include a solvent lubricating-oil plant, catalytic polymerization unit, and facilities for producing tractor fuel.

Process and power steam will be provided at the plant, but electric power will come from the Electricity Board. G. A. C.

1407. Work progresses on Europe's largest oil refinery. Anon. *Refiner*, 1950, **29** (12), 107–8.—Planned output of the new $100 million project in b.d. is crude naphtha and white spirit, 42,500; kerosines, 6000; diesel fuels and gas oils, 14,000; light fuel oils, 6000; bunker fuel, 30,000; and asphalts, 3500—giving more than 5 million tons (U.S.) of petroleum products per year. The project was first announced in Nov. 1946, work began in June 1949, and completion is scheduled for Jan. 1952. The plant will include a 37,000-b.d. cat cracker. R. W. G.

1408. Installation, operation and maintenance of mechanical-drive steam turbines. W. B. Yard. *Oil Gas J.*, 22.3.51, **49** (46), 92.—Rigid substantial foundations are necessary for steam-turbines, and steam-piping to and from the machine should be designed to eliminate strains on the turbine casing, protect it from exhaust pressures, and make it possible to work on machine without shutting down entire plant.

Periodic check will ensure smooth operation of a turbine; and at periodic shutdowns careful and complete inspection should be the order. G. A. C.

1409. Pressure testing methods and equipment. Anon. *Mech. World*, 20.4.51, **129** (3353), 355.—The majority of pressure testing is done hydraulically because of its convenience and safety, and pneumatic testing is reserved for special cases where hydraulic testing is impracticable. Pneumatic testing must always be carried out with the greatest care because of the energy stored in a compressed gas. In extreme cases where large-capacity containers are involved the amount of water required to fill the cylinders might be too heavy to be supported by the cylinders and their foundations. The advantages of using water for hydraulic testing are that it is cheap, clean, and can usually be removed without difficulty after the test. In cases where water cannot be used for reasons of corrosion or freezing a good substitute is paraffin. Before starting a pressure test all orifices must be closed up securely. When testing hydraulically all air must be bled away before attempting to apply the test pressure, and vents may have to be provided at any high points. The system is first filled with water at low pressure, either from the ordinary water supply or by means of a centrifugal pump. The test pressure is applied by a reciprocating pump operated by hand, power-driven reciprocating pumps being confined to large installations.

A. S.

1410. Velocity distribution and fluid friction in smooth concentric annuli. R. R. Rothfus, C. C. Monrad, and V. E. Senecal. *Industr. Engng Chem.*, 1950, **42** (12), 2511–20.—The isothermal flow of air at room temp through two smooth, horizontal, concentric annuli has been studied by measurement of point velocities and static pressure differentials. Data are presented for various Reynolds No. in the viscous, transition, and lower turbulent flow ranges. Velocity distribution and pressure losses in viscous flow are in agreement with theoretical relationships. Both viscous and turbulent flow patterns are believed to exist simultaneously in the transition range. The radius of maximum velocity in fully developed turbulence appears to be predicted by viscous flow equations. Turbulent flow friction factors are affected by radius ratio, and are higher than those calculated from hydraulic radius. The outer pipe common to both annuli has been operated without a core. Velocity profiles and pressure drops are in satisfactory agreement with data of other investigations. Friction factors to annuli have been correlated by the hydraulic-radius concept applied to the portion of the fluid section outside the radius of max velocity. Turbulent flow velocity profiles in the annuli have been correlated with open-pipe data through a geometrical modification of the u^+,y^+ relationship. (Authors' abstract.) F. M.

1411. Air humidification coefficients in spray towers. Gas-film mass transfer coefficients at low air velocities for use in scrubber design. G. F. Bonilla, J. R. Mottes, and M. Wolf. *Industr. Engng Chem.*, 1950, **42** (12), 2521–5.—A study was made of the performance of three small hollow-cone spray nozzles of different orifice dia in spraying water into air in an empty tower. Mass-transfer coefficients for the system

air–water were determined over a range of water and low air-flow rates—rates that might be employed in a scrubbing tower. The tower used for the investigations was large enough (3 ft in dia) that the wall effect was believed to be negligible. Empirical equations indicating the effect of flow rates and tower height on the mass transfer coefficients at 75° F were developed. Equations were also developed for K_Ga in terms of nozzle water pressure for variations in nozzle size and for other vapours or gases. Thus the results should be helpful in the design of spray scrubbers for the scrubbing of any gas from air with water in the ranges of conditions covered, providing the gas film is the controlling factor. (Authors' abstract.) F. M.

1412. Testing natural gasoline plant operating efficiency. J. B. Armstrong. *Refiner*, 1950, **29** (12), 125–8.—(*25th Anniversary mtng of the California Natural Gasoline Assoc*).—The paper reports a test procedure used to determine the overall plant-operating efficiency as it applies to extraction of LPG and gasoline in the absorption plant only. (Author's abstract.) R. W. G.

1413. Investigation of centrifugal pumps of various speeds. K. Rütschi. *Schweiz. Arch. Ang. Wiss. Tech.*, 1951, **17**, 33–46.—Results of the behaviour of different types of centrifugal pumps under variable conditions are given, and the evaluation of the data obtained is represented by several graphs, intended to be of service to pump-design engineers. T. R.

1414. Packed-tube heat transfer. M. Leva. *Industr. Engng Chem.*, 1950, **42** (12), 2498–501.—Heat-transfer data are presented for air flowing through packed tubes in which the ratio of particle to tube dia is extremely high (>0·35). Using tubes of 0·5, 0·75, and 2·0 inches, packings investigated include glass beads, copper cylinders, porcelain balls, clay balls, brass rings, and Raschig rings. The heat-transfer coefficients observed were unexpectedly high, and within experimental limits tube dia had no effect upon the transfer coefficients. The following empirical correlation is suggested :—

$$\frac{Nu}{Re^{0.75}} = 0{\cdot}125$$

where Nu is a modified Nusselt number hDp/k based upon D_p, the effective particle dia. The arrangement of spherical packings along the inside wall is discussed in relation to the void space and subsequent channelling, and it is concluded that the use of high ratios of particle to tube dia in contact catalysis is undesirable. F. M.

1415. The movement of cohesionless granular bed by fluid flow over it. R. A. Bagnold. *Brit. J. Appl. Phys.*, 1951, **2**, 29. J. T.

Distillation

1416. Creole's new atmospheric-vacuum unit is one of world's largest. Anon. *Oil Gas J.*, 5.4.51, **49** (48), 78.—The 63,000-b.d. capacity new atmospheric and vacuum distillation unit at refinery of Creole Petroleum Corp., Standard Oil Development Co, Amuay Bay, Venezuela, is described.

27·1° API gravity high-cetane and 26·1° API gravity 102 low-cold-test Tia Juana crudes are processed, the plant being sufficiently flexible to produce a wide selection of quality intermediates from both atmospheric and vacuum stages.

Adequate protection against corrosion is provided by alloy coatings up to ¼ inch thick in critical corrosion needs.

The two-stage crude distillation unit in the new refinery of Anglo-American Oil Co. at Fawley, England, is essentially a duplicate of the Creole unit. G. A. C.

1417. New distillation column. Anon. *Petroleum*, Feb. 1951, **14** (2), 44.—Describes a new rotary concentric-tube distillation column, having a high efficiency factor for fractional distillation, which has recently been developed at the U.S. National Bureau of Standards by C. B. Willingham, V. A. Sedlak, J. W. Westhaver, and F. D. Rossini. For high values of throughput—2 to 4 litres of liquid per hour—the distillation column, when operated at 4000 r.p.m., is claimed to have an efficiency factor about ten times those previously reported for other rectifying columns. R. E. P.

1418. Punched card devices for distillation calculations. A. Rose and T. J. Williams. *Industr. Engng Chem.*, 1950, **42** (12), 2494–7.—The use is described and illustrated of punched-card computors for plate-to-plate calculations of binary and ternary steady-state continuous distillations when simplifying assumptions are applicable. The application to stepwise plate-to-plate calculations of batch distillation with appreciable hold-up is also described, together with suggested methods for extending the procedure to cases where simplifying assumptions are not applicable. F. M.

1419. Binary batch distillation. Relation between number of plates, reflux ratio and pole height. M. T. Cichelli, W. D. Weatherford, Jr., J. R. Bowman, and J. Coull. *Industr. Engng Chem.*, 1950, **42** (12), 2502–10.—Equations are developed relating the previously developed concept of pole height as a measure of sharpness of separation in binary batch distillation, to number of plates and reflux ratio with the simplifying assumptions of negligible hold-up, constant molal downflow, and constant relative volatility. Graphs and equations are presented which enable rational design, and operation of batch distillation columns for an desired degree of separation of a binary mixture where the charge composition and relative volatility are specified. F. M.

1420. Patents. N. Max, assr to Shell Development Co. U.S.P. 2,514,961, 11.7.50. A process for the recovery of aldehydes from crude aldehydic reaction products.

G. J. Pierotti, A. E. Handlos, and C. M. Reider, assrs to Shell Development Co. U.S.P. 2,514,966, 11.7.50. The refining and concentrating of crude unsaturated aldehydes of extractive distillation at sub-atmospheric pressure and temperature below 35° C, and in the presence of a sufficient amount of water to maintain a single liquid phase in the distillation zone.

G. J. Pierotti, assr to Shell Development Co. U.S.P. 2,514,967, 11.7.50. The refining of crude unsaturated aldehydes by extractive distillation, viz., acrolein mixed with propionaldehyde and acetone to separate high-purity acrolein. C. F. S.

Absorption and Adsorption

1421. A system of process calculations for light hydrocarbons. Part III. Absorption. A. L. Hutchinson. *Refiner*, 1950, **29** (12), 97–103. (See Abs. Nos. 658 and 1033.)—The series is concerned with a method of using printed forms to expedite the work of process-plant calculations. Part I treated the basic principles of light hydrocarbon process-plant calculations, Part II dealt with vapour–liquid flash computations, while Part III deals with absorption calculations. R. W. G.

1422. Adsorption of methane on fuller's earth. W. T. Granquist. *Industr. Engng Chem.*, 1950, **42** (12), 2572–5.—The adsorption of methane on crude and extruded fuller's earth has been investigated at the temp of boiling methane. Adsorption isotherms at other temp over the range 112° to 123° K have been calculated by the method of Polanyi from the experimental isotherm. Isobaric and isosteric plots have been obtained by cross-plotting the Polanyi isotherms, and the isosteric heat of adsorption has been determined. The results of this work have been compared with earlier adsorption work involving nitrogen on the same clay at liquid nitrogen temp. (Author's abstract.) F. M.

1423. Efficiency characteristics of commercial absorbers. E. G. Ragatz. *Refiner*, 1950, **29** (12), 117–24. (*25th ann. mtg California Natural Gasoline Assoc.*)—Data obtained during last several years from 275 tests on seventy-five absorbers ranging in operating pressure from 45 to 2100 p.s.i.g. reported and analysed. The efficiency relationships developed by the study indicate that: (1) absorption columns can be designed to operate at extraction efficiencies in excess of majority of currently operating commercial units; (2) when recoveries of order of 90% are required, employment of super-efficient columns is highly profitable; (3) design of such super-efficient columns requires careful attention to development of high individual tray efficiencies; and (4) the straight-line-chart technique enables various factors affecting tray efficiencies to be evaluated. R. W. G.

1424. Patents. A. E. Hirschler, assr to Sun Oil Co. U.S.P. 2,514,580, 11.7.50. The separation of hydrocarbons by means of a granular adsorbent is described. A third hydrocarbon is added to the mixture, which is then passed in liquid phase through the adsorbent.

C. L. Dunn, assr to Shell Development Co. U.S.P. 2,514,968, 11.7.50. Acrolein is separated from a mixture comprising acrolein and propionaldehyde by rectified absorption.

B. E. Hudson, assr to Standard Oil Development Co. U.S.P. 2,515,006, 11.7.50. Tertiary olefins are removed from mixtures of hydrocarbons by selectively absorbing the olefins by contacting the mixture with an aqueous solution of a mixture of an organic sulphonic acid and a water-soluble polybasic mineral acid. C. F. S.

Solvent Extraction and Dewaxing

1425. Patents. M. J. Vold and R. W. Mertes, assrs to Union Oil Co. U.S.P. 2,514,733, 11.7.50. A sulphonation method for the preparation of a concentrate containing a metal sulphonate dissolved in a lubricating oil, where a lubricating-oil fraction is extracted with a solvent firstly to reject all material having a V.G.C. lower than 0·80, and then subjecting to solvent extraction again to separate all material having a V.G.C. higher than 0·92, leaving a lubricating oil stock with a V.G.C. between about 0·80 and 0·92. This stock is sulphonated using fuming sulphuric acid and sulphur trioxide.

C. P. Strand, assr to Shell Development Co. U.S.P. 2,515,140, 11.7.50. Selective solvent separation of unsaturated hydrocarbons using an aqueous solution of a water-soluble silver salt and an organic amine salt of an inorganic acid. C. F. S.

Cracking

1426. Sun's new Houdriflow unit. P. D. Barton. *Oil Gas J.*, 29.3.51, **49** (47), 232.—The new catalytic cracking unit at the Toledo refinery of the Sun Oil Co. is described.

Additional new facilities include a crude unit, vacuum feed-preparation unit, and a gas-recovery unit.

The combination crude catalytic cracking plant is rated at 40,000 b.s.d., and includes a naphtha reformer and a twelve-case catalytic cracking unit of the fixed-bed type.

Tables list inspections of Houdriflow charge components, Houdriflow unit-design heat balances, typical charge and yields and plant survey on one reactor.

Operating results over several months have been satisfactory. G. A. C.

1427. High destruction thermal cracking of catalytic cycle oil. D. M. Little and G. E. Merryfield. *Oil Gas J.*, 29.3.51, **49** (47), 242.—High destruction thermal cracking of catalytic cycle oil has been achieved on both pilot and large-scale plants.

Successful cracking of cycle oil at high crack per pass requires a radiant-type heater with high uniform heat-transfer rates and short residence time. Aniline-point reduction of gas-oil charge correlates well with conversion and yield; highest octane ratings are obtained on once-through operation at low pressure.

Higher gasoline yields are obtained by recycle cracking than once-through operation, but octane ratings are lower for same aniline-point reduction of gas oil.

Four figures and five tables are given. G. A. C.

1428. Two reaction chambers in series increase refinery charge rate. Anon. *Oil Gas J.*, 8.3.51, **49** (44), 94.—Approx 25% increase in throughput of a U.O.P thermal cracking plant at Santa Fe Springs, Calif., has been achieved by incorporation of a second reaction chamber. Thus the combined heavy and light charge processed through two heaters enables high temp to be maintained through both chambers, giving a higher rate of cracking charge, without altering design of furnaces.

G. A. C.

1429. Platforming natural gasoline—its potentialities for the industry. W. F. Fulton. *Refiner*, 1950, **29** (12), 107–12.—(*Regional Mtg, Natural Gasoline Assoc. of America, Tyler, Texas.*)—Under certain conditions the platforming process is well suited to use in natural-gasoline plants for improvement of octane number, and in some cases may be specifically adopted for the production of aromatics. Platforming

is economical in raising octane numbers of fractions boiling between 150° and 400° F, having sufficient quantities of naphthenes and normal paraffins to be converted to aromatics and *iso*-compounds. Where sufficient naphthenes are present, the process may be employed in the production of benzene and toluene. Several tables are presented, giving conversion figures and indicating blending suitability. R. W. G.

Polymerization

1430. Butylene from ethylene. Cobalt–carbon catalyst. H. A. Cheney, S. H. McAllister, E. B. Fountain, J. Anderson, and W. H. Peterson. *Industr. Engng Chem.*, 1950, **42** (12), 2580–6.—A pilot-plant investigation of a process for polymerizing ethylene to butylene over a cobalt–carbon catalyst at temp below 150° C and at pressures of 1 to 100 atm is described. The catalyst is prepared by treating coconut charcoal with cobalt nitrate and subsequent decomposition. The carbon is an essential catalyst ingredient and not merely a support. A large number of catalysts were investigated, the final choice being a 20 to 100 cobalt–charcoal. The reaction was investigated in a flow apparatus, and the variables studied included temperature, pressure and dilution, space velocity, and feed impurities. The polymer consists of olefins having even numbers of carbon atoms, and is predominantly straight chain. Under suitable operating conditions polymerization per pass averaged 50%, with the product containing 75% butylenes, 15% hexylenes, and 10% higher-boiling olefins. Catalyst lives in excess of 165 kg of polymer per litre of catalyst were obtained, and polymer production rates of 300 g/litre of catalyst per hr are possible. F. M.

1431. Non-catalytic polymerization of olefins to lubricating oils. F. M. Seger, H. G. Doherty, and A. N. Sachanen. *Industr. Engng Chem.*, 1950, **42** (12), 2446–52.—Non-catalytic polymerization of a number of olefins was studied batch-wise in a rocking bomb of conventional type, and the products evaluated as lubricating oils. Thermal polymerization of 1-decene was studied at temp from 400° to 850° F and under optimum conditions, 600° F, 10 hr, 250 to 500 p.s.i.g., gave 65% by weight of an S.A.E. 10 oil with a V.I. of 140 and a pour point of −10° F. Other olefins from ethylene to dodecene were investigated, as well as mixed olefins and cracked products. Normal 1-olefins gave the best results, and the preferred range is from *n*-hexene to *n*-dodecene. Some flow experiments were conducted to show that the process could be developed commerically if suitable olefinic charging stocks are economically available. F. M.

1432. Patents. F. W. Banes and M. W. Swaney, assrs to Standard Oil Development Co. U.S.P. 2,514,362, 11.7.50. Describes a method of utilizing arylalkylolamines as stabilizers for emulsion polymer lattices; 0·05 to 2 weight per cent, based on the polymer, of *N*-phenyl, substituted alkylolamines is added.

F. W. Banes and E. Arundale, assrs to Standard Oil Development Co. U.S.P. 2,514,363, 11.7.50. Describes the method of utilizing alkyl phenol–hydroxyalamine mixtures as stabilizers against further polymerization of a synthetic rubber latex.

E. T. Bishop and R. D. Sullivan, assrs to Shell Development Co. U.S.P. 2,514,928, 11.7.50. Polymerizing branch-chain hexadienes in the presence of 0·1 to 5·0% by weight of *tert*-butyl hydroperoxide to produce light-coloured, non-toxic, rubber-like materials.

F. W. Banes and P. K. Frolich, assrs to Standard Oil Development Co. U.S.P. 2,514,986, 11.7.50. An improvement to the process for the production of liquid polymers, where the resulting oily polymer is dissolved in a solvent and filtered. C. F. S.

Alkylation

1433. Patents. W. A. Schulze and C. E. Stoops, assrs to Phillips Petroleum Co. U.S.P. 2,514,419, 11.7.50. A process for the catalytic alkylation of a phenol with a mono-olefin, mixing both with a C_3–C_5 paraffinic hydrocarbon diluent, and contacting the mixture with a catalyst under alkylation conditions.

D. B. Luten and G. M. Good, assrs to Shell Development Co. U.S.P. 2,514,960, 11.7.50. The dealkylation of alkylphenols by contacting poly-alkyl-substituted phenols in the vapour phase with a synthetic catalyst. C. F. S.

Isomerization

1434. Catalytic isomerization of 1-hexene. E. A. Naragon. *Industr. Engng Chem.*, 1950, **42** (12), 2490–3.—The vapour-phase isomerization of 1-hexene was investigated over several catalysts in a fixed-bed isothermal unit. The products were hydrogenated under conditions which did not result in isomerization of 1-hexene and the hydrogenated material separated by distillation into narrow-boiling fractions subsequently analysed by mass spectrometer. Octane ratings are also recorded. Activated alumina, boria–alumina, phosphoric acid, acid-treated Doucil, and U.O.P. cracking catalyst (type B) were the most active catalysts tested. Results are tabulated for all catalysts at temperatures of 500°, 600°, 750°, and 900° F and L.S.V. of 0·5 vol/vol/hr. By comparison with equilibrium data of the hexenes it is shown that approx equilibrium mixtures of the hexenes together with some lower- and higher-boiling hydrocarbons were obtained at some temps in the 500° to 900° F range. Isomerization and hydrogenation occurred when 1-hexene was treated over molybdena–boria–alumina at 600° to 775° F in the presence of hydrogen. F. M.

Chemical and Physical Refining

1435. Industrial petroleum chromatography. H. Weil. *Petroleum*, Jan. 1951, **14** (1), 5–12.—The main subject of the paper is to answer the question—"where will chromatography fit in the petroleum field?" Part 1 reviews the principles and origin of petroleum chromatography, covering the period 1900–31.

It is submitted that methods have now been designed which make it possible to carry out commercial petroleum fractionation as a practically continuous operation, thereby eliminating the economic shortcomings hitherto caused by the typical batch-character of chromatographic treatment. R. E. P.

1436. Removal of corrosive sulphur compounds from gasoline. R. Glaser and J. Kuropieska. *Nafta*, Dec. 1949, **5**, 372–6.—Authors describe doctor and Cu strip tests on gasoline and two methods of sweetening using: (1) $Ca(OCl)_2$; (2) MeOH + NaOH. The technical details of the treatment are given and optimum conditions described. Results are tabulated. M. S.

1437. Patents. C. M. Floyd, assr to Standard Oil Development Co. U.S.P. 2,514,997, 11.7.50. Desulphurization of non-aromatic hydrocarbon fractions with a poly-olefin glycol under conditions to form a raffinate and an extract phase, the sulphur-free hydrocarbons being recovered from the raffinate.

C. Mack, assr to Standard Oil Development Co. U.S.P. 2,515,131, 11.7.50. Describes an improved process for desulphurization, but is more particularly claiming a process for the regeneration of the desulphurizing catalyst (bauxite), where the spent catalyst is burnt with oxygen-containing gas at a temp 1000° to 1400° F, and then treated with ammonia.

J. B. Stripling, assr to Socony-Vacuum Oil Co. U.S.P. 2,515,141, 11.7.50. A method of stabilizing a doctor-sweetened mixture of hydrocarbons and the regeneration of caustic solutions. C. F. S.

Special Processes

1438. Carbon black manufacture. Anon. *Petroleum*, Nov. 1950, **13** (11), 285–8.—Describes the carbon-black plant at Ellesmere Port, Cheshire, which is owned by Cabot Carbon Ltd. The plant is designed for a max output of 60,000 lb *Vulcan* 3 carbon black, operating on a 24-hr-day basis.

The production process described is a modified version of the furnace method to produce carbon black from imported petroleum-refinery residues. Advantages claimed are: (1) It is cheaper to transport oil residues than carbon black from abroad. (2) The utilization of exhaust gases obviates the purchase of fuel and cuts operating expenses. (3) A high efficiency and yield, no black is wasted as smoke. (4) The use

of petroleum residues as the only raw material required. (5) Process is flexible, several grades of black can be produced economically without altering the furnaces.
R. E. P.

1439. Kubierschky's principle and interaction between powdered solids and gases or vapours. C. Jeanprost. *Chim. et Ind.*, 1951, **65**, 191–9; 339–47.—Kubierschky's principle (1907) is that of the "superposition of densities," *i.e.*, gas flow over finely divided materials is so arranged that increasing gas density causes regular circulation, thus ensuring good contact between gas and solid. Construction of columns for such processes, heat exchange, and rate of fall of particles therein are discussed, with particular reference to metallurgical and other inorganic applications, but also including low-temp coal carbonization and catalytic processes such as the Fischer–Tropsch.
V. B.

1440. Patent. W. J. D. van Dijck, assr to Shell Development Co. U.S.P. 2,515,145, 11.7.50. A process for the incorporation of hydrophilic material into organic media, viz., Prussian blue into stand oil, where the Prussian blue is first treated with *iso*butyl alcohol.
C. F. S.

Metering and Control

1441. The organisation of an industrial instrument department. O. G. Pamely-Evans. *Mech. World*, 30.3.51, **129** (3350), 287.—The problem of instrument maintenance is naturally dependent on the size of the factory using them. It also becomes more important with the age of the instruments. In any factory using gas, electricity, water, steam, and compressed air there will be pressure gauges, thermometers, ammeters, voltmeters, wattmeters, thermostats, flow meters, and pyrometers. Generally these instruments are not adequately maintained, and sooner or later the remedy is the very expensive one of replacing suspected parts by new units. It is essential therefore that a suitable routine maintenance scheme should be organized, and this scheme should be put into operation as soon as an instrument enters a factory. As instrument work combines both mechanical and electrical techniques, this type of duty should be allocated to someone like an electrician interested in model-making or a fitter interested in wireless. Without doubt this type of work is for a tradesman. Any man selected for the job of organizing a maintenance department can receive training by being sent to makers of the instruments used, as most large instrument manufacturers run instructional courses regularly. The layout of a comparatively small shop required for instrument work is of the greatest importance, and a typical arrangement is described and illustrated. A method of keeping adequate records is also described. The above organization suggested may appear to be over-elaborate, but when it is considered that the marketability of products depends on the accuracy of the instruments used in the various processes it will be appreciated that the cost of an efficient maintenance department will be very small compared with the losses which might result from instruments which are not functioning properly.
A. S.

1442. Accuracy in the measurement of instantaneous fluid flow. A Pallez. *Chim. et Ind.*, 1951, **65**, 43–55.—Background of French standard *X* 10–101, "Measurement of instantaneous fluid flow" is given, and the standard itself is discussed in some detail. The pressure unit employed is the bar. Possible inaccuracies of the method are considered, and criticisms of the standard are outlined.
V. B.

Products

Chemistry and Physics

1443. Thermochemistry for the petroleum industry. Part XIV—Some miscellaneous hydrocarbons. K. A. Kobe and R. E. Pennington. *Refiner*, 1950, **29** (12), 93–6. (See Abs. Nos. 787, 2196, 2197, 2198, 2199, 2200, 2201, 2202, 2203, 2204, 2205, 2499—1950, and 436—1951.)—Data are presented for the free energies of formation, heats of combustion, and molecular weights of gaseous *cyclo*propane, *neo*pentane, *iso*pentane, and *o*-, *m*-, and *p*-xylene. Heat capacities, enthalpies, mean heat capacities, and heat-

capacity equations are given for *cyclo*pentane from 0° to 700° C, and for *neo*pentane, *iso*pentane, and *o*-, *m*-, and *p*-xylene from 0° to 1200° C. The thermochemical data for the pentanes are of importance for isomerization calculations, and the formation of *o*-, *m*-, and *p*-xylenes in hydroforming operations is becoming of increasing importance. R. W. G.

1444. Alkylnaphthalenes. Part VI. 1 : 3-Dimethylnaphthalene. R. F. Evans and J. C. Smith. *J. Inst. Petrol.*, 1951, **37**, 80–90.—An improved method over that reported in Part I is described of preparing 1 : 3-dimethylnaphthalene. A. R. W. B.

1445. Chemical equilibrium in vinylnaphthalene formation from ethylnaphthalene at low pressures. J. C. Ghosh and S. Rama Das Guha. *Petroleum*, Nov. 1950, **13** (11), 283–4.—Data are presented for the chemical equilibrium in the dehydrogenation of β-ethylnaphthalene to β-vinylnaphthalene at low pressures of 10 to 40 mm, and at 380° to 500° C over a Cr_2O_3–Al_2O_3–Cu catalyst. The equilibrium constants have been calculated from the equation :—

$$Kp = \frac{\alpha^2}{1-\alpha^2}\frac{P}{760}$$

where α is the degree of dissociation of a gram mol of ethylnaphthalene and p the reaction pressure in mm Hg.

The free energy change of the reaction, heat of reaction, and the entropy change of the reaction, evaluated from the observed values of the equilibrium constant by standard methods are, at 298° K, 19,712 cal, 27,278 cal, and 25·39 enthropy units respectively. R. E. P.

1446. Activation of nickel catalyst by hydrogen. L. Kh. Freidlin and N. I. Ziminova. *Izvest. Akad. Nauk S.S.S.R., Otdel. Tekh. Nauk*, 1950, 659–61.—Experiments on Ni cat prepared from Ni_2Al_3 show that it is activated by H_2 and that de-activation of the cat can be accomplished by removal of H_2 therefrom by easily reducible substances (*e.g.*, nitrobenzene, vinyl-butyl-ether). Such removal is accomplished by agitation of suspension of cat in toluene with the substance to be reduced, in temp range 20° to 60° C. 1 ml of the cat (2·33 g) can lose a max of 223 to 224 ml H_2; residual cat is inactive in further hydrogenation tests. Results show that activity of Ni cat is linked with pyrophoric properties, the inactive cat being non-pyrophoric and vice versa. V. B.

1447. Hydrogenation and dehydrogenation reactions on α- and β-cobalt. A. M. Rubinstein and N. A. Pribuitkova. *Izvest. Akad. Nauk S.S.S.R., Otdel. Khim. Nauk*, 1951, 70–80.—Cobalt cat was prepared by decomp of $Co(NO_3)_2$ and reduction of the oxide by H_2, either without or with carrier (active C); cat in latter case contains 25% Co. Reduction at low temp (320° to 360° C) gave α (hexagonal) form, at temp >600° C pure β (cubic) modification occurs. Cat activity was tested by hydrogenation of benzene, *cyclo*hexene, acetone, ethylene, CO, and dehydrogenation of *cyclo*hexane and ethyl alcohol. α form and mixture of α and β is more active than β alone. Inactivity of latter is due to high reduction temp required for its formation. Cat prepared at intermediate temp, containing appreciable amounts of β form, has high activity; thus showing that β form is not merely inert carrier for the α. V. B.

1448. Polymerization mechanism of propylene and structure of its dimers and trimers. L. I. Antzus and A. D. Petrov. *Izvest. Akad. Nauk S.S.S.R., Otdel. Khim. Nauk*, 1950, 599–607.—Previous work is reviewed at some length. Experimental investigations were carried out on a polymer fraction having b.p. 132° to 136° C, containing di-, tri-, and tetra-mers of propylene, with considerable preponderance of the trimer; examination being made of the oxidn products. Formation of the trimer occurs by isomerization of the dimer to dialkylalkenes (mainly 3 : 3-dimethylbutene-1) to which propylene becomes attached. Isomerization also occurs in the trimer formed. Among the nonenes there were identified 3-ethyl-4 : 4-dimethylpentene, 3 : 4 : 5-trimethylhexene-2 and (less definitely) 3 : 4-dimethylheptene-3. Thus polymerization of *n*-olefins (propylene) can be used for synthesis of highly branched hydrocarbons, even containing a quaternary C atom. V. B.

1449. Hydrolysis of propylene. Sulphuric acid solutions to *iso*propyl alcohol. R. W. Schrage and E. H. Amick, Jr. *Industr. Engng Chem.*, 1950, **42** (12), 2550–3.—The effect of temp and composition on the percentage of total propylene as *iso*propyl sulphate in propylene–sulphuric acid solutions was studied. It was found that for acid concentrations up to 70% (on a propylene-free basis) less than 25% of the propylene present was esterified at all temp up to the normal boiling point, and that less than 35% was esterified even for 80% acid. The effects of acid concentration propylene–sulphuric acid mol ratio, and operating pressure on the yields of products batch distilled from propylene–sulphuric acid solutions were also investigated. By reducing the pressure to about 250 mm absolute during the distillation of 61·5% acid, yields were realized which were equivalent to those from 46·0% acid, distilled at atmospheric pressure under otherwise similar conditions. Although yields of *iso*propyl alcohol from 69·5% acid can be improved by reducing the pressure during distillation, it does not appear that they can, at moderate pressure reductions, be made equivalent to those obtained from 46% acid. (Authors' abstract.) F. M.

1450. Vapour–liquid equilibria at sub-atmospheric pressure. K. C. Bachman, A. Zimmerli, and E. L. Simons. *Industr. Engng Chem.*, 1950, **42** (12), 2569–71.—Vapour–liquid equilibrium data at 760, 380, and 190 mm for the system trichloro-ethylene–tetrachloro-ethylene, and at 380, 190, 95, and 47·5 mm for the system ethylphenyl acetate and ethyl-α-phenyl butyrate are reported and the variation of relative volatility with pressure calculated. The vapour–pressure–temperature relationships for ethylphenyl acetate and ethyl-α-phenyl butyrate have been determined. F. M.

1451. Catalytic hydrocondensation of carbon monoxide with olefins. 5. Hydrocondensation of carbon monoxide with propylene. N. D. Zelinskii, Ya. T. Eidus, K. V. Puzitzkii, and M. I. Batuev. *Izvest. Akad. Nauk S.S.S.R., Otdel. Tekh. Nauk*, 1950, 647–53. (Cf. Abs. No. 424—1950.)—Experiments were carried out on equimolecular mixture of H_2 and C_3H_6 + 5·7 to 7°% of CO, under the same conditions as previously. 85 to 90% of the C_3H_6 reacts, 35% being reduced to C_3H_8 and 5% going to C_4 compounds. Analyses are given of the gaseous and liq reaction products. Liq material (above C_4) has b.p. 30° to 325° C and contains 35% unsaturateds, proportion of these latter decreasing with rise in b.p. Examination of the hydrogenated liq material showed approx equal amounts (13%) of C_5 and C_{7-9} and about 20% of C_6; *iso* compounds were present in the C_{5-8} range. V. B.

1452. Bond relationships in higher aromatic hydrocarbons based on new accurate determinations of their heats of combustion. A. Magnus and F. Becker. *Erdöl u. Kohle*, 1951, **4**, 115–18.—Resonance energy can, according to quantum-mechanical theory, be calc from heat of combustion, and minor variations in such energy should be detectable by accurate measurements. A special vacuum-jacketed metal-block calorimeter was designed in which temp changes of $2 \cdot 10^{-4}$° C are detectable; checks on benzoic acid gave a mean error of 0·012%. Heats of combustion were determined for twelve higher aromatic hydrocarbons, and effect of non-planar molecular structure, hydrogenation of the middle C atoms, and "anellation" (ortho-fusion) on resonance energy as found by experiment and by theory compared. Fair agreement was obtained, indicating that such factors can be reliably calculated. V. B.

1453. Hydrocarbon syntheses in the *cyclo*butane series. I. 1, 3 dimethyl*cyclo*butane. B. A. Kazanskii and M. Yu. Lukina. *Izvest. Akad. Nauk S.S.S.R., Otdel. Khim. Nauk*, 1951, 47–56.—A ten-stage synthesis of 1 : 3-dimethyl-*cyclo*butane, starting from *iso*butyl alcohol, is described in detail, including experimental procedure and yields for each stage. Fractionation of the final product shows two forms to exist, *trans-* and *cis-*, having following respective constants; b.p. 57·4° to 57·6°; 60·5° to 60·6°; n_D^{20} 1·3896, 1·3933; d_4^{20} 0·7017, 0·7106. V. B.

1454. Films of hydrocarbon–stearic acid mixtures. H. Sobotka and S. Rosenberg. *J. Coll. Sci.*, 1950, **5**, 581–5.—The formation of monomolecular layers on a barium buffer hypophase and of built-up Y-films is described for various mixtures of stearic acid with *n*-octadecane, *n*-octacosane, and *n*-hexatriacontane. The thickness of the resulting mixed films is interpreted with reference to their structure. The existence

of a limiting proportion of 1 mol of hydrocarbon to 2 mol of stearic acid is explained by the crystal structure of the films. The relationship between three-dimensional and two-dimensional molecular compounds containing aliphatic acids is discussed. (Authors' abstract.) H. C. E.

1455. Temporary reductions of viscosity of liquids at high rates of shear. W. J. Morris and R. Schnurmann. *Nature*, 1951, **167**, 317.—At sufficiently high rates of shear, any liquid consisting of elongated molecules will show a decrease of coefficient of visc with increasing rate of shear. This is shown for tetradecane between 6° and 35° C, using a jet viscometer. If p = pressure difference along a capillary of radius r, and t is the time of efflux of a given volume V of liquid, then the rate of shear $R = \left(\frac{dv}{dr}\right) = 4V/\pi r^3 t$. For each temp the plot of pt *versus* $\log_{10}R$ gives a line passing through a minimum at *ca* $\log_{10}R = 5{\cdot}5$.

Similar results are obtained with castor oil, liquid paraffin, transformer oil, and mineral oils. H. C. E.

1456. Spreading of liquids on low energy surfaces. I: Polytetrafluoroethylene. H. W. Fox and W. A. Zisman. *J. Coll. Sci.*, 1950, **5**, 514–31.—Almost all pure liquids (except water) spread on most clean solids, and although ways of modifying the solid surface have been described (Abs. Nos. 722—1948; 899—1947) by deposition of monolayers, the study of such systems is limited to liquids which are not good solvents for the monolayers. It is now found that liquids will not spread on the surface of polytetrafluoroethylene (TFE) unless the surface tension γ is <20 dynes/cm. This paper lists γ and contact angle θ for n-alkanes, di(n-alkyl)ethers, n-alkylbenzenes, and polymethylsiloxanes, and some miscellaneous hydrocarbons and esters, all on TFE.

It is found that for each homologous series of liquids $\cos\theta$ is a linear function of γ, and the spreading coefficient (= work of adhesion − work of cohesion) can be calculated as a function of γ. It is concluded that the Young–Dupré relation fits the experimental results, but the Doss and Rao relation for the surface condensation leads to such high values for the high-boiling liquids as to make it unlikely that the latter theory is correct. H. C. E.

1457. Films of omega-branched fatty acids. H. Sobotka, S. Rosenberg, and A. Birnbaum. *J. Coll. Sci.*, 1950, **5**, 557–80.—This investigation deals with the effect of terminal branching upon the behaviour of long-chain aliphatic acids. Monomolecular layers of these compounds, spread on buffer solutions, are characterized by determination of the force/area relationship. On the basis of their minimum molecular area in condensed films, the tilt of the molecule against the surface was computed, and various possibilities for the conformation of the terminal groups were evaluated. The capability of building up polylayer films on a solid surface and the character of such films reflects the shape of the molecule and its deviations from the prismatic form. A number of surface phenomena are treated such as contact angles, surface reflection, and skeletonization by dissolving the free fatty acids in the film. Although films of branched fatty acids resemble those of normal fatty acids in several points, a striking difference is revealed by their enormous surface volatility. Molecular sublimation of branched fatty acids across blankets of stearic acid, several hundred A thick, is an important manifestation of the dynamic state prevailing in crystalline polymolecular films. (Authors' abstract.) H. C. E.

1458. Phenomenon of successive ignition. P. G. Ashmore and R. G. W. Norrish. *Nature*, 1951, **167**, 390–2.—Chloropicrin vapour at pressures of 1 to 2 mm Hg eliminates the low-pressure ignition peninsula of CO and O_2. If CO and O_2 are admitted to a reaction vessel which has previously been used for investigations with chloropicrin, a series of blue flashes are obtained, each accompanied by a sharp pressure fall. The frequency of ignitions varies from 2 sec to 2 min from run to run, and ignitions do not always occur under similar conditions. Ignitions have been recorded between 670° and 830° C at pressures well within the low-pressure ignition peninsula.

Possible explanations of this phenomenon are discussed. It would appear that traces of chloropicrin vapour decompose at the furnace temp, and the decomposition products form equilibrium reactions. The enhanced temp of the CO flame then

displaces this equilibrium to give inhibitors which quench the ignition. Alternatively, successive inflows of chloropicrin inhibitory decomposition product may occur and quench the ignition. When this product has been destroyed the flame is renewed. H. C. E.

1459. Viscosity-temperature dependence. I. Williamson. *Nature*, 1951, **167**, 316.—The equation $\eta = a\eta/T + b$ for the change of visc η and temp T does not fit all data as suggested by Branker (Abs. No. 692—1951).

The visc of three organic liquids between −40° and 150° C, when plotted in the form η *versus* η/T do indeed give approx straight lines; but when the equation is transformed into the analogous form $1/\eta = 1/b - a/bT$ and $1/\eta$ is plotted against $1/T$, curved lines are obtained. The explanation of this paradox is that the variation of $1/T$ only 0·5 is over the range −50° to 150° C, so that in the method adopted by Branker only minor deviations from the line $\eta = \eta$ will occur. The plot of $1/\eta$ against $1/T$ shows clearly that the proposed equation does not hold. H. C. E.

Analysis and Testing

1460. Petroleum. H. Levin. *Anal. Chem.*, 1951, **23**, 231–7.—This review of progress in analysis in the field of petroleum takes into consideration the literature for approximately one year from that covered in the previous review. 173 references. J. S.

1461. Hydrocarbons in petroleum. F. D. Rossini. *Petroleum*, Mar. 1951, **14** (3), 61–3.—This article is a summary of the recent important work of the American Petroleum Institute Research Project 6 carried out at the United States National Bureau of Standards. The problem is the separation of the complex mixture of hydrocarbons which is petroleum and the obtaining of unaltered major constituents in a substantially pure state. Brief details of separations attained are given, using the standard processes of fractionation. The processes used are distillation, extraction, adsorption, and crystallization, which depend, respectively, on the properties of vapour pressure, solubility, adsorbability, and freezing point. R. E. P.

1462. Natural and synthetic rubbers. N. Bekkedahl. *Anal. Chem.*, 1951, **23**, 243–53.—This review covers both chemical methods of analysis and physical testing of natural and synthetic rubbers, and refers to articles appearing in the literature for the year ending about Oct. 1950. 219 references. J. S.

1463. Review of analytical chemistry. Anon. *Anal. Chem.*, 1951, **23**, 2–101.—Third Annual Review of recent developments in the various fields of analytical chemistry during the year 1950. J. S.

1464. Analytical distillation. Round table discussion. A. Rose. *Anal. Chem.*, 1951, **23**, 529–30.—The discussion dealt in succession with concentric-tube columns, effect of non-adiabatic operation, total-reflux distillation, test mixtures, interpretation of distillation curves, spiral-screen columns, and spinning-tube columns. These specific items introduced the more general subjects of apparatus, procedure, testing, and interpretation. J. S.

1465. Fisher-Tag testers promote product safety. Anon. *Laboratory*, 1951, **20** (3), 81.—This brief article describes flash-point apparatuses, their characteristics, and the products for which they are best suited. C. N. T.

1466. High temperature viscometer. N. H. Spear and L. P. Herrington. *Anal. Chem.*, 1951, **23**, 148–51.—A high-temp viscometer has been developed to measure accurately viscosities of new heat-transfer liquids currently under development. Instruments available either do not have the temp range investigated or do not possess satisfactory accuracy in this range, because high-temp viscosity standards are not available.

The viscometer developed to fill this need is calibrated at ordinary temperatures, has a range to over 300° C, and measures with an accuracy better than 5%. Small volumes of test liquids are required, and no hazardous liquid baths are employed.

Viscosity for three liquids are reported and compared with previous investigations. The unique features of the instrument are its simplicity, flexibility, and accuracy in viscometry at high temperatures. Such an instrument has been needed by physicists, chemists, and engineers for proper investigation of high-temp viscosities in the fields of heat transfer and lubrication, as well as for better scientific understanding of the effect of temp on viscosity. J. S.

1467. Zahn viscosimeter makes viscosity tests in 30 seconds. Anon. *Laboratory*, 1951, **20** (3), 74.—A description is given of the cup-type Zahn viscometer, which has a corrosion-resistant cup of 44 cc capacity. Five different orifice sizes are available, covering max practical ranges of about 100 up to nearly 2000 cp. Flow-times are usually less than 1 min, and are recorded in Zahn seconds. C. N. T.

1468. Titrimetry in glacial acetic acid. P. C. Markunas and J. A. Riddick. *Anal. Chem.*, 1951, **23**, 337–9.—This work was undertaken to investigate the possible applications and limitations of titrations in glacial acetic acid. Over 400 compounds were tested, including salts of strong bases and weak acids, salts of weak bases and weak acids, and weak bases. This study should provide a simple and rapid method for the analysis of carboxylic acid of salts of many bases and for a large number of organic bases whose ionization constants (in water) are 10^{-12} or greater, and should replace the lengthy and tedious procedures now used for the analysis of these compounds. J. S.

1469. Luminol as a chemiluminescent indicator in acid-base titrations with a dark-chamber titrimeter. F. Kenny and R. B. Kurtz. *Anal. Chem.*, 1951, **23**, 339–41.—Luminol indicator is a new type of acid-base indicator which emits light at the end point. It was developed to make possible acid-base titrations in solutions having sufficient colour to prevent the use of ordinary indicators and, at the same time, avoid the use of a potentiometric titration. The indicator, consisting of luminol, haemoglobin, and hydrogen peroxide, emitted light at a pH very close to the stoichiometric point in the titration of 0·1M-hydrochloric acid with 0·1M-sodium hydroxide. The presence of a highly coloured component, such as gentian violet, did not interfere with the end-point. No indicator error was observed in the titration in either colourless or coloured solutions. This new indicator should have wide application in titrating a variety of coloured solutions. J. S.

1470. Modern trends in spectroscopy. A. C. Menzies. *J. Roy. Soc. Arts*, 23.2.51, **99** (4841), 283.—Paper is a verbatim report of a Peter Le Neve Foster lecture given on 13.12.50. Types of spectra classified, and grating spectrograph, in which light is dispersed by a diffraction grating instead of a prism, and various types of grating used are described. Mention made of developments in control of electrical excitation, and application of photoelectric cells in measurement and recording of lines. In absorption field, advances reviewed in design of ultra-violet and visible spectrophotometers, and in infra-red spectrometers, including development of high-sensitivity detectors and use of devices for polarizing incident radiation.

Advances have been made in new materials; developments in growing of large crystals has made possible production of larger prisms for use in infra-red and far ultra-violet regions.

Raman effect and sources and spectrographs for Raman spectra are discussed, together with methods for scanning and recording the spectra.

Micro-waves are most recent region for spectroscopic observation, and wavelengths are now of appreciable size. Here spectroscopy is principally concerned with measurement of absorption of radiation by gases at low pressures. X-ray spectroscopy, modern X-ray spectrometers, and Geiger–Mueller equipment, and their applications, are reviewed. Thirteen literature references are given, and discussion following lecture reported. U. M.

1471. Spectrophotometric analysis of accelerator-rubber mixtures. K. E. Kress. *Anal. Chem.*, 1951, **23**, 313–23.—Ultra-violet spectrophotometric analysis of seven common organic accelerators in rubber is described. Chloroform solutions of 10 to 25% accelerator as a master batch stock containing a single- or a two-component

accelerator were analysed with a degree of rapidity, accuracy, and precision believed adequate for routine control. Emphasis is placed on ease and adaptability of the method for the analysis of two-component accelerator stocks. Absolute and relative compositions were determined by accepted mathematical procedures. J. S.

1472. Aromatic hydrocarbons in some diesel fuel fraction ultra-violet spectrometric identification. N. G. Adams and D. M. Richardson. *Anal. Chem.*, 1951, **23**, 129–33.—The degrading effect of aromatic hydrocarbons on the combustion characteristics of diesel fuels has stimulated an interest in their detection and analysis. The present study was undertaken to investigate the extent to which ultra-violet-absorption spectra could be used in the identification of the aromatic hydrocarbons in a 400° to 500° F distillate from West Edmond crude oil. Specific aromatic hydrocarbons identified in this boiling range include tetralin, naphthalene, 1- and 2-methylnaphthalene, 2-ethylnaphthalene, diphenyl, and 2 : 6-, 1 : 6-, and 1 : 7-dimethylnaphthalene. In addition, the presence of the following are indicated : 2-methyl-5 : 6 : 7 : 8-tetrahydronaphthalene, 1 : 3-dimethylnaphthalene, and a methyldiphenyl. Data are presented in the form of forty consecutive fractions, and should provide valuable information concerning the azeotropic displacement of the boiling points of these hydrocarbons; in the development of analytical methods for the quantitative determination of these materials, and the utility and limitations of ultra-violet spectra in the study of aromatic hydrocarbons in petroleum fractions of this boiling range.
J. S.

1473. Compound types in gasoline by mass spectrometer analysis. R. A. Brown. *Anal. Chem.*, 1951, **23**, 430–7.—The determination of compound types in gasoline fractions has been the object of considerable attention by petroleum chemists during the past twenty-five years. Numerous methods have been developed, based on chemical reactions and physical constant data which are, in general, characterized by the need for skilled analysts and rather time-consuming laboratory measurements. In view of the frequency demonstrated ability of instrumental analysis to accomplish what conventional methods cannot, mass spectra data were studied to determine if such data properly used could supplant or supplement other methods of type analysis. Results of the study consist of a mass spectrometric method which is quick and reasonably accurate, and requires only 0·001 ml of sample. Hydrocarbon types are determined, except for *cyclo*paraffins and mono-olefins, which are grouped. These latter compounds may then be resolved by chemical analysis, such as nitrosation or bromination. The method can probably be used directly or by other mass-spectrometer users. In addition, its principle can be extended to obtain type analysis of higher-boiling petroleum fractions and mixtures of non-hydrocarbon compounds.
J. S.

1474. Infra-red analysis of five C_{10} aromatics. J. A. Perry. *Anal. Chem.*, 1951, **23**, 495–7.—The need for a means of analysing mixtures of five C_{10} aromatics led to the method presented which was designed to be rapid and accurate, and to have maximum simplicity of execution. No dilution of standards or of samples was required in either calibration or analysis. Measurement of cell length and absorbancy were eliminated by the condition of normalization and the use of reference wavelengths, respectively. The accuracy is shown to compare favourably with similar reported work, the error being 0·5% absolute over the whole percentage range. An infra-red normalized multi-component analysis of hydrocarbon liquids can be set up under the following restrictions, each of which materially simplifies performance of the analysis; assumption of the validity of Beer's law, no dilution of standards or samples, and no knowledge of the length or absorbancy of the rock-salt cell. J. S.

1475. Spectrographic determination of phosphorus in lubricating oil by solution excitation. P. G. Pagliassotti and F. N. Porsche. *Anal. Chem.*, 1951, **23**, 198–200.—In applying spectrographic techniques to the determination of phosphorus in oils, the problem of how to introduce the sample into the analytical gap between the discharging electrodes is overcome by means of a solutions-excitation apparatus in which the lower electrode is a rotating graphite disc, partially immersed in the oil. J. S.

1476. Sweetening and desulfurization of light petroleum products. Part II.—Analysis of sulphur compounds in light petroleum distillates. V. A. Kalichevsky. *Refiner*, 1950, **29** (12), 113–15. (See Abs. No. 1042.)—The methods of testing for various sulphur compounds are reviewed and discussed. Twenty-seven references to the literature are given. R. W. G.

1477. Distribution and type of sulphur compounds in straight-run naphthas. J. H. Hale, C. J. Thompson, M. G. Barker, H. M. Smith, and J. S. Ball. *Anal. Chem.*, 1951, **23**, 287–93.—The purpose of this research was to gain knowledge of the distribution of the types of sulphur compounds in crude petroleum, and the effect of temp on this distribution. It was found that the types of sulphur compounds present in the distillates differ considerably, depending on both the crude-oil source and distillation temperature. Sulphur compounds that are not reactive in the scheme of analysis used are predominant, and hence little is known of their composition, except that they are changed by heat to more reactive types. The presence of elemental sulphur was established in certain crude oils. The variations in types of sulphur compounds present calls for different methods of refinery processing. The effect of heat in changing types of compounds present is significant, and the presence of elemental sulphur is also of importance to refiners. J. S.

1478. Determination of *n*-paraffins in gasoline, oils, and paraffin waxes. W. Luthe. *Anal. Chem.*, 1951, **23**, 493–5.—Chemical processes with hydrocarbons of various boiling ranges (gasoline, oils, waxes) frequently require knowledge of their contents of *n*-paraffins and *iso*paraffins, which has required tedious or expensive experiments; an easily workable chemical method for providing this information fills a definite need in hydrocarbon analysis. The method described is based on a simple chemical reaction with antimony pentachloride, followed by an indirect determination of the *n*-paraffins which have not been affected by this reagent, while the *iso*paraffins are converted into insoluble tarry matter. An accuracy of about 3 to 6% of total sample may be reached. The method applies also to other substances such as olefins, alcohols, fatty acids, etc., after they have been converted to hydrocarbons by usual methods. There are many possibilities of applying this simple and cheap analytical method in scientific and commercial hydrocarbon processes, as in most cases the contents of branched or normal chains in the source material, in the intermediates, and in the final products reflects largely on the efficacy of the process and on the quality of the products. J. S.

1479. Low temperature separation of ethane from methane and air. R. L. Slobod. *Anal. Chem.*, 1951, **23**, 361–3.—In geochemical methods of prospecting for oil, gas samples containing methane, ethane, and heavier hydrocarbons and air are frequently obtained in which the ethane and heavier hydrocarbon fraction must be determined. A method has been developed using liquid nitrogen at reduced pressure to separate the ethane quantitatively from the methane and air. In order to carry out this procedure conveniently, a special trap has been designed incorporating a low-temp reservoir containing liquid nitrogen maintained at reduced pressure. This low-temp source cools a container of liquid nitrogen open to the atmosphere for easy accessibility. A broader application in the field of low-pressure gas analysis is suggested by the data obtained, showing an incomplete recovery of pure ethane from the gas phase when liquid nitrogen at atmospheric pressure is used as the refrigerant. Consequently, liquid nitrogen at reduced pressure is suggested for any separation of ethane when complete recovery is required. J. S.

1480. Development of extreme pressure lubricants. W. Davey. *Petroleum*, Nov. 1950, **13** (11), 279–82.—The development of suitable lubricants for use under extreme pressure or temperature conditions is described. Chemical composition and the mode of action are discussed and the relative performances under test conditions given. Wear–load diagrams and friction–time curves given were obtained using a laboratory Four Ball Machine. They do not represent the actual service performance, but serve to illustrate several important aspects of development.

Extreme-pressure lubricants function by reacting chemically with metal surfaces to form friction-reducing films, thus free or reactive sulphur forms sulphide or sulphate

films, halogen compounds form halide films, and phosphorus compounds phosphide films.

The most satisfactory performance under high-speed shock conditions is stated to be obtained by combined chlorine–sulphur lubricants. R. E. P.

1481. Stability test for additive oils. Anon. *Petroleum*, Jan. 1951, **14** (1), 13–14.—Describes a new evaluation test for lubricating oils with additives, which simulates the characteristic deposits found in engine tests of motor oils. The test was developed by S. A. McKee and A. R. Fritz of U.S. National Bureau of Standards.

The method consists essentially of circulating the oil sample in a thin film over a heated steel strip, similar to the oil film on an engine cyl wall. A mechanical lubricator pump delivers the oil to the upper end of the thin steel strip, which is in an inclined position and maintained at the test temperature. Oil leaving the lower end is recirculated. The amount of deposit on the strip provides a sensitive means for rating the lubricating oil under test.

Advantages claimed are that the test requires only simple laboratory apparatus; is time-saving; is less expensive, and eliminates the fuel variable that results from contamination of the oil by the engine fuel in the conventional method. The test gives a quantitative as well as visual rating of oil, providing more consistent results and reducing the subjectivity of individual operators. R. E. P.

1482. Interfacial tension and membrane tension from pendent drop shape, with special reference to emulsions. S. Matthews. *J. Oil Col. Chem. Assoc.*, **34** (367), 1.—A brief résumé is given of the theory of interfacial tension, particularly with reference to oil/glue solution emulsions, which gel at an interface and form membranes. Of methods investigated for measurement of interfacial tension the pendent drop shape proved the most useful. Tables according to Fordham, connecting the ratio S of the two dia of a pendent drop with an inverse function $1/H$ and appearing in an equation for boundary tension of the drop, are included. The apparatus is described and illustrated. 1% glue solutions were used. Aspects considered are effect of spreading coefficient on pendent drop shape, reduction of boundary tension by glue adsorption, and membrane formation by matured linseed oil/glue solution interface. A discussion on the physical state of the membrane is included. The solid nature of the mature linseed oil/glue solution membrane, if not stretched beyond its elastic limit, is confirmed by the observations made on the drop, e.g., a membrane formed on a certain shape retains this shape even when expanded. Advantages of the method include having only one interface under investigation. Changes in interfacial tension can be studied without breaking the interface or removing its anchorage, etc. The method can also be used to detect hydrophilic impurities in oils. D. K.

1483. Retraction test for serviceability of elastomers at low temperatures. O. H. Smith, W. A. Hermonat, H. E. Haxo, and A. W. Meyer. *Anal. Chem.*, 1951, **23**, 322–7.—Elastomer vulcanizates progressively stiffen as the temperature is lowered. Additional stiffening, due to crystallization, may occur as exposure to low temperature is prolonged. The available methods of testing the low-temperature flexibility of rubber and rubber-like materials do not reveal the losses in flexibility caused by crystallization except by using prolonged storage at low temperatures. A retraction test employing large deformations, which greatly increases the rate of crystallization, has been developed. This test rapidly gives a temp index correlating with the stiffness of elastomer vulcanizates after storage at low temp, and can be used to measure the merit for low-temp applications of both crystallizable and non-crystallizable elastomers. This test in conjunction with conventional (room-temp) tests has been used successfully to study the low-temp performance of Hevea, GR-s, Paracril, and polybutadiene vulcanizates along with vulcanizates of many experimental elastomers. Correlations of results with cold compression set and hardness after low-temp storage has been excellent, and substantiates the usefulness of the test. J. S.

1483a. Coatings. T. G. Rochow and R. W. Stafford. *Anal. Chem.*, 1951, **23**, 212–16.—This review concerns the analysis of coatings and includes organic high polymers and their associated oils, pigments, and solvents. General schemes for the analyses of organic coatings and resinography are considered, as well as monographs on the analysis of separate parts of organic coatings, including resins, relevant oils, pigments, and specific constituents or functional groups. 164 references. J. S.

1484. Draft German standards for liquid [diesel] fuels. W. Bieler. *Erdöl u. Kohle*, 1951, **4**, 122–6.—Following draft standards are reproduced and brief explanatory notes appended. Filtrability of diesel fuels (DIN 51770), method (Hagemann and Hammerich, cf. Abs. No. 1225—1936) consists in noting temp at which flow time of given quantity of fuel through a specified filter exceeds 60 sec. Cold stability (paraffin wax separation) of diesel fuels (DIN 51772), substantially a cl. pt. test. Ignition quality (cetane No.) of diesel fuels (DIN 51773), a general ignition delay procedure is described without, however, definite engine requirements being specified, although a single-cyl engine is preferred. V. B.

1485. Filtrability as an indication of the cold-stability of diesel fuel. T. Hammerich and H. Stoll. *Erdöl u. Kohle*, 1951, **4**, 119–22.—Low-temp operating difficulties (pumpability, filter blockage) are discussed. Visc increase will not cause trouble till 75 cs is attained, which is improbable in German climate with fuel to current German standard (E_{20} 2·6° max). Pour and cl. pt. are inadequate criteria fully to indicate potential difficulties with waxy fuels. Description is given of filtrability tester based on engine-operating equipment; seven fuels were evaluated, and results compared with laboratory filtrability test according to DIN 51770 (cf. Abs. No. 1484). Findings indicate that latter test should preferably be carried out using two filter sizes (0·10 and 0·15 mm) instead of with the smaller size alone. The closer together the limiting filtrability temp for the two filters, the higher the probability that operating troubles will ensue. Owing to engine warmth actual operation can be carried out at up to about 6° C below temp of laboratory results. V. B.

1486. Determination of water in solid fuels and certain petroleum products by the Karl Fischer method. G. Salvi and C. Siniramed. *Riv. Comb.*, 1950, **4** (2), 94–105.—Extension of Karl Fischer's method for water determination to solid fuels and to some petroleum products has been studied. The method is applicable with good results, provided that hard solid fuel samples are passed through a 4900-mesh sieve to allow an intimate contact between fuel particles and Karl Fischer's reagent. For petroleum products the addition is necessary of an anhydrous solvent (alcohol–benzene), which acts as binding agent and ensures single liquid phase for titration. (Authors' summary.)

Crude Oil

1487. Characteristics of crude oils currently processed in the United States. H. M. Smith. *Oil Gas J.*, 29.3.51, **49** (47), 308.—The crude-oil-producing areas of the U.S. are divided into eight geographical areas, and certain characteristics of the crude oils produced in each area discussed. Characteristics based on Bureau of Mines routine analysis, include contents of sulphur, asphalt, naphtha, gas oil, aromatics in both naphthas and gas oils, and naphthenes in paraffin–naphthene portions of both the naphthas and gas oils.

A total of 330 crudes oils are considered, and four figures are given. G. A. C.

Gas

1488. Some problems of the utilization of natural gas by the (Italian) coal gas industry. G. Bosinelli. *Riv. Comb.*, 1950, **4** (6), 317–31.—Natural-gas utilization by the coal-gas industry depends on economic and technical factors related to the particular situation of different gas undertakings.

Author considers that Italian gas industry will face its problems of peak loads and of optimum heating value by extending the practice of mixing natural gas with different coal gases. (Author's summary.)

Engine Fuels

1489. Aviation fuels. D. Read. *Oil Gas J.*, 15.3.51, **49** (45), 68.—Several methods of producing aviation fuels and some recent data illustrating the application of these methods are presented.

Fluid catalytic cracking, alkylation, platforming, and aviation-gasoline blending are discussed.

Conclusions reached include statements that existing catalytic cracking units can be utilized more advantageously to process heavy gas oils rather than the light stocks processed during the last war; and that the platforming process can be effectively utilized to relieve present shortage of aromatics and increase potential supply of aviation fuels.

The platforming process can also be applied to increase production of aromatics from straight-run and natural gasolines, and straight-run naphthas can produce 80 and 91/96 grade aviation fuels.

Thirteen tables and four figures illustrate the article. G. A. C.

1490. Aircraft gas-turbine fuels. H. A. Murray. *Oil Gas J.*, 29.3.51, **49** (47), 218.—The general requirements of military and commercial gas-turbine fuels, their availability, cost, fire-hazard, low-temperature properties, volatility and effect on combustion stability, heating valve odour, and fuel specifications are discussed.

Four figures and five tables illustrate the article. G. A. C.

1491. The problem of tractor fuel in Italy. Part 1. C. Padovani, V. Berti, and G. Leidi. *Riv. Comb.*, 1950, **4** (7–8), 411–32.—Problem of tractor fuel in Italy is considered, with particular reference to the use of Middle East distillates of very low octane number. Octane requirements of 32–35 ASTM Motor method can be met by addition to tractor fuel of low-boiling fractions, by addition of ethyl alcohol, and by anti-knock agents, both organic and metallorganic. Advantages of the different methods are reported and discussed. (Authors' summary.)

1492. Experimental and theoretical studies of flame-front stability. G. H. Markstein. *J. Aero. Sci.*, 1951, **18**, 199–209. (*Heat Transfer and Fluid Mechanics Institute mtng, Los Angeles, June* 1950.)—A detailed investigation is described of the phenomenon whereby rich propane and other hydrocarbon flames burning in tubes assume a cellular structure in the absence of turbulence in the approach stream. All the hydrocarbons examined, with the exception of methane, gave cellular flames on the rich side of stoichiometric composition, the average cell size decreasing with molecular weight of the fuel and increasing markedly with reductions in pressure; the addition of small amounts of hydrogen to lean mixtures of hydrocarbons, including methane, also caused strong cell formation.

A first-order perturbation treatment of flame-front stability, which gives results in qualitative agreement with experiments when account is taken of the dependence of burning velocity on flame-front curvature, is also presented. N. L. A.

Lubricants

1493. Lubrication progress. J. Groff. *Bull. Ass. franç. Tech. Pétrole*, 1951 (85), 3–20.—A lecture, presenting a rapid survey of lubrication theory, modern developments in lub oils, and recent researches on lubrication. V. B.

1494. Motor-oil additives. J. C. Geniesse and W. Schreiber. *Oil Gas J.*, 29.3.51, **49** (47), 302.—A review of lubricating-oil additives for oxidation and corrosion inhibition, detergency, and rust prevention is given, and measurement of wear by use of radioactive tracers discussed.

Four figures illustrate the article. G. A. C.

1495. Polymeric additives for synthetic ester lubricants. F. J. Glavis. *Industr. Engng Chem.*, 1950, **42** (12), 2441–6.—Solubility and visc data are presented for several acrylic polymers in various ester-type synthetic lubricants. Data on a single polymer blend in di-2-ethylhexyl sebacate are given to illustrate the general discussion of visc–temp relationships; the V.I. of Dean and Davis and the ASTM slope are chosen for the purpose of comparison. In general, improvement in both properties is obtained where the polymeric additive is soluble in the particular ester involved. F. M.

1496. Review of German synthetic lubricants. W. A. Horne. *Industr. Engng Chem.*, 1950, **42** (12), 2428–36.—A review of the processes used in Germany during 1939–45 for the production of synthetic lubricants, with particular reference to the hydro-

carbon class consisting of ethylene polymers, higher olefin polymers, and the condensation products of chlorinated paraffins and naphthalene. Flow diagrams are given for the production of ethylene from ethane, for the polymerization of ethylene, for the polymerization of higher olefins, and for the production of synthetic oil by condensation. A brief account of the ester-type synthetic lubricants is included.
F. M.

1497. Functional selection of synthetic lubricants. R. G. Larsen and A. Bondi. *Industr. Engng Chem.*, 1950, **42** (12), 2421–7.—The properties of synthetic lubricants, such as hydrocarbon polymers, polyalkylene oxides, poly-ethers, esters, alkyl halides, amines, silicones, fluorocarbons, and polymer blends, are tabulated and discussed. Properties selected for comparison are flow properties, such as visc, V.I. range, and low-temp suitability, high-temp characteristics, oxidation characteristics, solubility, and cost. These data are used in a stepwise process to select the best lubricant for a given application and to act as guide to the properties to be expected of a given blend.
F. M.

1498. Structural guides for synthetic lubricant development. C. M. Murphy and W. A. Zisman. *Industr. Engng Chem.*, 1950, **42** (12), 2415–20.—The literature concerning the prediction of visc–temp relationships of liquids is reviewed. Preference is given to ASTM equation

$$\log \log (\mu + c) = A \log T + B$$

the graph of which is linear over a wide temperature range. The slope of this line, designated S, is used as a convenient measure of the visc–temp characteristics, and is plotted against visc for a large number of hydrocarbons, ethers, and esters. Using this relationship the properties of hydrocarbons, ethers, poly-ethers, thio-ethers, mono-, di-, tri-, and tetra-esters, silicones, perhalocarbons, and amines are discussed, and general structural guides for the development of synthetic lubricant fluids are presented. F. M.

1499. Polyalkylene glycol synthetic lubricants. W. H. Millett. *Industr. Engng Chem.*, 1950, **42** (12), 2436–41.—Laboratory test data on a series of commercial polyalkylene glycol synthetic lubricants and greases compounded therefrom are reported. Visc characteristics, wear test, using a modified S.A.E. E.P. lubricant testing machine, vane pump test data, and bearing-temp data, using worm-gear reducers are reported for several lubricants and compared with standard mineral oils. In general, the polyalkylene glycols exhibit excellent anti-wear properties, have high V.I., low pour points, and do not sludge at high temps. No details of actual structures are given, the lubricants tested being referred to by trade names only. F. M.

1500. Flow characteristics of organopolysiloxane fluids and greases. C. C. Currie and B. F. Smith. *Industr. Engng Chem.*, 1950, **42** (12), 2457–62.—Some of the rheological properties of organopolysiloxane fluids alone and compounded with lithium soaps have been determined using a pressure viscometer and a rotational viscometer. The siloxane fluids exhibit either Newtonian or pseudoplastic flow, depending upon the mol. wt., and it is shown that the rate of shear has little effect upon the calculated visc–temp slope. The rheological behaviour of the siloxane greases is determined by both the concentration of soap and type of organopolysiloxane fluid, the latter being the major factor in the temp dependence of the greases under shear. F. M.

1501. Mode of action of phenothiazine type antioxidants. C. M. Murphy, H. Ravner, and N. L. Smith. *Industr. Engng Chem.*, 1950, **42** (12), 2479–89.—The oxidation inhibition action of phenothiazine-type compounds on a di-ester lubricating oil has been investigated in a dynamic system over the temp range 160° to 175° C in the presence of metal catalysts. Di-(2-ethylhexyl) sebacate was chosen as the reference ester, and a wide variety of derivatives of phenothiazine were used. The results are tabulated showing the induction period at various temp, visc changes, colour, acid numbers, metal catalysts, wt and appearance, and the formation of sludge and lacquer. The reaction mechanism is discussed, and it is suggested that resonance-stabilized free radicals, capable of reducing peroxides, are the actual inhibiting configurations. A number of high-mol.-wt. derivatives of phenothiazine with little tendency to volatilize

were investigated and shown to be as effective as the parent compound. This is of importance in high-temp applications, as lubricants used in turbine-powered engines and greases for use in silicone-clad motors and generators. F. M.

1502. Chlorotrifluoro-ethylene polymers. Physical properties. W. H. Reysen and J. D. Gibson. *Industr. Engng Chem.*, 1950, **42** (12), 2468–71.—The relationships between mol. wt, visc, density, and vapour pressure of a number of fractions of chlorotrifluoro-ethylene liquid polymers, of mol. wt. from 550 to 1300, are summarized in tabular and graphical form. The data may be used to determine the physical properties of any sample of chlorofluor-lube in the specified mol. wt. range between temp 100° and 210° F, if one property at a given temp is known. F. M.

1503. Lubricants produced by reactions in glow discharge. R. S. Whiteley, C. W. Kimberlin, G. L. Matheson, and R. W. Richardson. *Industr. Engng Chem.*, 1950, **42** (12), 2471–9.—A study of the products obtained by submitting a variety of organic compounds to " voltolization " is described. Two " voltolizers " were used, a glass-tube Voltolizer of 2 litre capacity and a Trommel Voltolizer of 5 to 20 gal capacity. Details of the equipment and electrical circuits used are given. Raw materials investigated include fatty oils, acids and alcohols, esters, lubricating-oil fractions, petroleum, paraffin wax, and biphenyl. Several reactions appear to occur concurrently of which the most important are: (*a*) random polymerization and condensation, leading to a wide distribution of mol. wt.; (*b*) hydrogenation and dehydrogenation leading to an equilibrium unsaturation; (*c*) a general destruction of polar groups such as hydroxyl, carboxyl, and carbonyl.

Excellent aviation oils were produced from blends of selected mineral oils with " voltolized " rapeseed, sperm, and other fatty oils. Lubricating-oil addditives such as pour inhibitors and V.I. improvers are obtained by voltolization of petrolatum and paraffin wax. F. M.

1504. Thermal and oxidation stability of polymethylphenylsiloxane. C. M. Murphy, C. E. Saunders, and D. C. Smith. *Industr. Engng Chem.*, 1950, **42** (12), 2462–8.—Thermal oxidation studies of several polymethylphenylsiloxanes have been carried out in the presence of various metals. Up to 225° C no appreciable change was observed, but at 250° C an increase in visc occurs with evolution of volatile oxidation products. Increase in visc is attributed to the condensation of two or more siloxane radicals from which methyl groups have been ruptured. Increase in the phenyl content of the siloxane molecule increases the thermal stability, and polymethylphenylsiloxanes are more stable than polymethylsiloxanes. F. M.

1505. Boundary lubricating characteristics of organopolysiloxanes. C. C. Currie and M. C. Hommel. *Industr. Engng Chem.*, 1950, **42** (12), 2452–6.—The effectiveness of organopolysiloxanes as lubricants under thin-film conditions have been investigated employing a Falex lubricant test machine under conditions designed to measure the wear under boundary conditions and to measure the load-carrying capacity of various fluids. Various combinations of surfaces were used to show that methylpolysiloxane fluids are satisfactory lubricants for steel–zinc, steel–nylon, steel–cadmium, steel–babbitt, steel–bronze, and bronze–nylon. Methylphenylpolysiloxane fluids are satisfactory for steel–zinc, steel–chrome, and steel–cadmium. The effectiveness of the four fluids tested is compared with an S.A.E. 30 petroleum lubricant. F. M.

1506. Ring-oiled bearings of oil engines. E. Ingham. *Gas Oil Pwr*, 1951, **46**, 71.—The construction of the ring-oiled bearing and its method of operation are described. Rings can supply adequate oil for 4 inches of bearing on either side of the ring. Rings should be carefully made and handled so that they are able to rotate freely.

The correct amount of oil must be placed in the oil wells, and it must be of the correct viscosity. Oil must be changed when it becomes contaminated, or when its viscosity increases unduly, and when this becomes necessary the oil wells must be washed with solvent. H. C. E.

1507. Patents. T. I. Claussen and J. T. Rutherford, assrs to California Research Corp. U.S.P. 2,514,625, 11.7.50. A lubricating oil to which is added an inhibitor produced by heating an element selected from the group consisting of sulphur and selenium with a dialkyl sulphide.

E. L. Walters and H. E. Sipple, assrs to Shell Development Co. U.S.P. 2,514,982, 11.7.50. A stabilized lubricant comprising an oleaginous polymer and from 0·05 to 5% by weight of a polynuclear phenol.

E. Lieber and E. P. Cashman, assrs to Standard Oil Development Co. U.S.P. 2,515,015, 11.7.50. A lubricating-oil composition containing a pour depressant which is obtained by reacting a long-chain chlorinated aliphatic compound with naphthalene in the presence of a Friedel–Crafts catalyst, then further reacting with a Friedel–Crafts catalyst and with a phosphorous- and halogen-containing compound.

E. Lieber and A. F. Cashman, assrs to Standard Oil Development Co. U.S.P. 2,515,129, 11.7.50. A lubricant consisting of a waxy mineral lubricating oil with a pour depressant amount of a Friedel–Crafts condensation product of a sulphurized highly chlorinated paraffin wax with naphthalene.

A. J. Morway, assr to Standard Oil Development Co. U.S.P. 2,515,133, 11.7.50. A lubricating grease thickened with 3 to 30% by weight of a metal soap of aliphatic fatty material, 0·2 to 1% of a resinous, oil-soluble condensation product of di-*iso*butyl phenol and a formaldehyde reacted with a nitrogen base, and 0·02 to 0·5% of phenyl β-naphthylamine. C. F. S.

Bitumen, Asphalt, and Tar

1508. Recent engineer corps developments in airport pavement design. G. McFadden and T. Pringle. *Rds & Streets*, Feb. 1951, **94** (2), 43.—The second world war caused the rapid development of military aircraft, giving rise to many runway problems. Since then many important advancements have been made in evaluating existing runways, in full-scale load testing, and in theoretical analysis. Design curves have been established for rigid and flexible pavements for contact pressures over 100 p.s.i. for single and multiple wheels. Various supplementary investigations are discussed, including the special problem of jet-aircraft runways. R. H.

1509. Asphalt mulch for seeding and protecting runway areas. W. J. Garnhausen. *Rds & Streets*, Feb. 1951, **94** (2), 80.—Non-toxic bitumen cutback with a visc Saybolt Furol of 90 to 120 sec at 140° F has been successfully used as a mulching material to protect newly seeded ground and to promote grass growth in Ohio. One of the jobs carried out is described in detail. The seed-bed was prepared in the usual way, fertilizer added, and the seed sown. The soil was moistened and the area levelled and harrowed. The cutback was sprayed at a temp of 150° to 180° F. Although this particular job was done in hot, dry weather, grass penetrated within a few weeks. Erosion was thus prevented and a good grass cover obtained within a few months. The thickness of application was found to be important, as was the property of the bitumen film to crack without breaking the adhesion between it and the soil. R. H.

1510. Electronic chemistry and new road techniques. R. Tournaire. *Chim. et Ind.*, 1951, **65**, 179–85; 348–55.—A lecture examining, from the point of view of modern physico-chemical theories, the phenomena involved in road construction. Aspects discussed include properties of coal tar as a road material; adhesivity and other properties of binders; addition of rubber to roads (first tried in 1902); action of fillers; bitumen emulsions; soil stabilization, including test methods for the latter, new procedures (*e.g.*, use of acrylic acid), and desirable criteria for stabilized soils. Brief selected bibliography, with synopses, of recent papers. V. B.

Special Hydrocarbon Products

1511. Carbon black—its relationship to the natural gasoline industry. G. Kiddoo. *Oil Gas J.*, 5.4.51, **49** (48), 81.—Channel, furnace, and thermal processes for production of carbon black are described, and classifications for the product given.

Method of manufacture of carbon blacks largely determines where and how they may be used; for example, rubber-grade channel blacks are classified principally upon basis of ease of processing with rubber or upon their electrical conductivity, whilst thermal blacks have large particle sizes, are low priced, and used where high loadings of carbon black in rubber, particularly synthetic, are desired.

It is estimated that consumption of carbon blacks, particularly of oil and gas furnace blacks will considerably increase.

Seven figures give shipments, flow diagrams, effect of synthetic-rubber consumption upon carbon-black consumption, and carbon-black production for period 1935–52. G. A. C.

1512. The application of cutting fluids to machining operations. R. B. Niebusch and E. H. Strieder. *Mech. Engng*, Mar. 1951, **73** (3), 203.—The most important functions of cutting fluids are removal of heat, reduction of friction between tool and chip, and flushing the chips away from the cutting zone. These functions result in improved tool life, better surface finish, lower power consumption, and greater accuracy. However, the cutting fluid must be applied properly if it is to perform its functions efficiently. A large volume of clean fluid must bathe the cutting zone at all times, and experience shows that best results are obtained when this is supplied at little or no pressure. As to the amount of fluid required, it is recommended that the gals of cutting fluids per min should be equal to the max h.p. required for cut. Effectiveness of a cutting fluid can also be improved by suitable arrangement of the discharge from the relief valve into the supply tank. By arranging the discharge to flow to the remotest area of the supply tank the cutting fluid will be agitated and kept circulating. This method will reduce rancidity and bacterial growth, help to maintain emulsion stability and distribute the heat absorbed from the cutting operation throughout the whole of the fluid in the supply tank. Recommendations are made in connexion with the application of cutting fluids for various types of machining operations. The paper also describes relatively simple, inexpensive modifications which can be made to existing general-purpose cutting-fluid supply systems on many machine tools in use to-day. Such modifications can increase tool life by as much as 100% and in addition provide improved surface finish, greater accuracy, and many other benefits. A. S.

1513. Diffusion as a rate-limiting factor in the oxidation of transformer oils. R. Irving and C. N. Thompson. *J. Inst. Petrol.*, 1951, **37**, 67–79.—The relative rates of sludge and acid formation in various transformer oils and related products have been determined under conditions where the rate of oxygen diffusion limits the rate of oxidation. The reaction rates and product proportions were significantly different from those observed in accelerated laboratory tests under similar conditions but with excess oxygen. In particular, slower rates of oxidation were observed to result from limited oxygen access, and a slow sludge-formation process became evident. The catalytic effects of soluble copper and iron on the oxidation rates of various types of transformer oil have also been investigated. A. R. W. B.

1514. Patents. V. N. Ipatieff and H. Pines, assrs to Universal Oil Products Co. U.S.P. 2,514,546, 11.7.50. The process described is for the production of *cyclo*alkylperhydroindan hydrocarbons by effecting a hydrogen transfer reaction in the presence of an acid acting catalyst. Claim 13 gives a 1 : 3 : 3 : 6-tetraalkyl-1-*cyclo*alkylhexahydroindan.

W. R. Turner and R. G. Heiligmann, assrs to the Atlantic Refining Co. U.S.P. 2,514,979, 11.7.50. A wax composition containing propylene–butadiene polymer obtained by treating a propylene–butadiene mixture with a Friedel–Crafts catalyst. C. F. S.

Derived Chemical Products

1515. Amyl compounds from pentane. R. L. Kenyon, G. C. Inskeep, L. Gillette, and J. F. Price. *Industr. Engng Chem.*, 1950, **42** (12), 2388–401.—A staff-industry collaborative report on the manufacture of various amyl derivatives by the Sharples Chemicals Co. at Wyandotte, Mich., together with a brief historical survey of the development of the process at the original Belle plant. Flow diagrams, tables, and photographs of units illustrate the account of chlorination of pentane, hydrolysis of chloro-compound, esterification, manufacture of amyl phenols, amylnaphthalenes, and amyl mercaptans. Plant layout, raw-materials supplies, safety, economics, and general chemistry of process involved are discussed. F. M.

1516. Commercial production of acetone and methylethylketone. C. Padovani and G. Salvi. *Riv. Comb.*, **5** (2), 81–114 (*National Chemical Congress, Milan, Sept.* 17–23, 1950).—A method reported for the production on a commercial scale of acetone and methylethylketone (M.E.K.) from 2-propanol and 2-butanol.

Above-mentioned alcohols are easily prepared by sulphuric acid hydration of propylene, and 1-and-2-butenes, and of mixed olefins from cracking. Solvent characteristics of M.E.K. are emphasized, particularly in varnish and petroleum industries.

Researches have been carried out with the aim of obtaining catalysts efficient in alcohols dehydrogenation. The composition of M.E.K.–water–2-butanol azeotropes has been studied; for water determination the method of Karl Fischer has been employed.

Manufacture of ketones by catalytic dehydrogenation of synthetic alcohols from petroleum will probably succeed in competition with acetylene process. (Authors' abstract.)

1517. Ethylene oxide and its derivatives. — Buret. *Bull. Ass. franç. Tech. Pétrole*, 1951 (85), 56–64.—A review, covering the preparation of $(CH_2)_2O$, the preparation and properties of the glycols, and the reactions of ethylene oxide with alcohols, acids, Cl compounds, cyanides, H_2S, NH_3, amines. Polymerization of ethylene oxide can yield dioxan or synthetic waxes. Ethylene oxide is a satisfactory insecticide, and finds considerable application for this purpose. Present-day French production of ethylene oxide is 1200 tons/year, consumption being 1800 tons. V. B.

1518. Styrene—A historical survey. F. Armitage. *Petroleum*, Dec. 1950, **13** (12), 310–13.—Part 2, 1940–49, is given of a review dealing with the development of styrene as a commercial product.

The production of styrene by the aromatization of petroleum hydrocarbons is tied up with the Catarole process. Derivatives of styrene are considered with particular emphasis on copolymerization with butadiene, maleic anhydride esters, glyceride oils, oil-modified alkyd resins, and other resinous materials. R. E. P.

1519. Patent. H. S. Bloch, assr to Universal Oil Products Co. U.S.P. 2,514,533, 11.7.50. The patent describes Diels–Alder condensation products (surface-active agent) of certain polyolefinic, cyclic hydrocarbon fractions. C. F. S.

Coal, Shale, and Peat

1520. Petroleum industry has definite role in synthetic development. J. Boyd. *Refiner*, 1950, **29** (12), 77–85. (*A.P.I. Mtng, Los Angeles*, Nov. 1950.)—A general review of the present and immediate future of synthetic-fuel production in the U.S. Several references are made to the demonstration units set up by the Bureau of Mines in conjunction with private industry for the utilization of coal, oil shale, and natural gas. It is pointed out that if the U.S. is to be self-sufficient in its supply of liquid fuels, it must consider using alternatives to petroleum stocks—this will be of advantage in times of international difficulties. The ease of liquid fuel production from alternative stocks is in the order natural gas, oil shale, and coal. The first of these is already in demand as a fuel, and thus cannot be used to any great extent, whereas the use of the others is only at present hindered by the costs of operation, which are approaching those for petroleum itself. Sketches are given which indicate a surplus of supply over demand for petroleum for 1949–53, but a shortage of 2·5 to 4·8 billion brl/year by 1975. R. W. G.

1521. Humic acids from coal. Controlled air-oxidation of coals and carbons at 150° to 400° C. L. D. Friedman and C. R. Kinney. *Industr. Engng Chem.*, 1950, **42** (12), 2525–9.—The controlled air-oxidation of various grades of coal and several carbons has been studied at temp between 150° and 400° C. Optimum yields up to 90% of alkali-soluble coal acids were produced from bituminous coals at temp of 200° C. Temp above 200° C increased the rate of oxidation but decreased the overall yields of acids. Lignites and sub-bituminous coals although easily oxidized gave low yields of acid products. Anthracite, carbon black, lamp black, and graphite required higher oxidation temp, and the products of oxidation contained only traces of acidic material. F. M.

1522. Stages in the dissolution of coal. A. Gillet. *Nature*, 1951, **167**, 406.—Selective extraction of coal by, *e.g.*, pyridine differs from the almost complete solution obtained in hydrocarbons at *ca* 300° C. If this solution is held at its temp of generation much of the dissolved material is precipitated. The explanation is that in pyridine the complex is first decomposed chemically and selected portions are then dissolved; in hydrocarbons the whole dissolves, but the complex is unstable and decomposes to the same extent as with the pyridine as solvent. Solvents attack the coal both chemically and physically and the initial results depend on which processs occurs first.

This concept also explains other phenomena such as transient fusion and the existence of two forms of attritus. H. C. E.

Miscellaneous Products

1523. Butadiene as a chemical intermediate. J. H. Putman. *Chem. Prod.*, 1951, **14**, 126–9.—From a consideration of the U.S.A. synthetic-rubber production programme, carried out in the second world war, the importance of butadiene, formerly an impurity in petroleum, is indicated. The sources of butadiene, namely ethyl alcohol (grain or fermentation alcohol) and high-temp cracking of petroleum naphthas, are described and a table states the production of butadiene from these sources in 1943, 1944, and 1945.

The principle processes employed for producing butadiene by dehydrogenation of C_4 hydrocarbons are reviewed, also the methods for the purification, *e.g.*, azeotropic distillation using ammonia or sulphur dioxide as the entraining agent, extractive distillation using furfural, and absorption with cuprous ammonium acetate. Brief consideration is given to the properties and storage of butadiene, and the article concludes by briefly describing the rubber-like copolymers of butadiene with styrene or acrylonitrile. M. C. B.

1524. Utilization of butyl rubber in automotive inner tubes. D. J. Buckley, E. T. Marshall, and H. H. Vickers. *Industr. Engng Chem.*, 1950, **42** (12), 2407–13.—The causes of the failure of butyl rubber inner tubes under sub-zero service are discussed, and the investigations undertaken to eliminate such failures are described. The use of higher-molecular-weight butyl polymers plasticized with petroleum oils gave satisfactory products which were cheaper to produce and more easily processed than previously used compounds. F. M.

1525. Carbon disulphide. A. G. Arend. *Chem. Prod.*, 1951, **14**, 130–2.—The inflammability of carbon disulphide, and the tests required for assessing the suitability of this commodity, are considered briefly. The production of carbon disulphide by passing vaporized sulphur over heated coke, and by reaction between iron pyrites and carbon, is briefly reviewed, and the electric-furnace process, in which sulphur and coke are heated together, is described. The extensive solvent applications of carbon disulphide are enumerated, also other uses, *e.g.*, in the biocide field, in the purification of paraffin wax, and in chemical processes. M. C. B.

1526. Manufacture and uses of ethylene oxide and ethylene glycol. P. P. McClellan. *Industr. Engng Chem.*, 1950, **42** (12), 2402–7.—A review of the literature covering the manufacture of ethylene oxide *via* ethylene–chlorhydrin and by the oxidation of ethylene with air. The conversion of ethylene oxide to ethylene glycol is discussed in detail. Other reactions of ethylene oxide with alcohols, phenols, mercaptans, ammonia, amines, hydrogen cyanide, Grignard compounds, hydrogen sulphide, and sodium hydrogen sulphite are briefly reviewed. F. M.

1527. The stability of mineral oils in toilet and cosmetic preparations. W. W. Middleton. *J. Inst. Petrol.*, 1951, **37**, 45–58.—Toilet and cosmetic preparations containing mineral oils deteriorate during storage in unfavourable conditions. Deterioration is in part due to the instability of the oils themselves. In order to assess the stability characteristics, the oils and emulsions made from them were exposed to sunlight for four months and an order of deterioration established. Stability was found to be well indicated by the levels of bromine substitution values, aniline points, and the nature of the fluorescence of the oils in ultra-violet light. A. R. W. B.

1528. Use of petroleum coke in the (Italian) gas industry. L. Giuntini. *Riv. Comb.*, 1950, **4** (6), 347–55.—Petroleum coke from the Dubbs cracking plant at La Spezia has been successfully distilled in gas-works in the town of Varazze. The author reviews characteristics of petroleum coke, and describes its use in gas-works. (Author's summary.)

1529. Iodine and bromine in deep oil well brines. W. Chajec. *Nafta*, Dec. 1949, **5**, 366–72.—Author summarizes methods of determination of I′ and Br′ in solutions and gives a list of Carpathian and Subcarpathian I′ and Br′ bearing brines with the view to extraction of these elements. World producers and consumers of I_2 are listed. M. S.

1530. Patents. E. G. Marhofer, assr to Phillips Petroleum Co. U.S.P. 2,514,714, 11.7.50. An insecticide composition made up from an effective quantity of a contact insecticide and a resinous clay-tower polymer.

W. A. Stover and A. N. Sachanen, assrs to Socony-Vacuum Oil Co. Inc. U.S.P. 2,515,139, 11.7.50. A new composition, alkylthiophene characterized by a nuclear-substituted hetero-halogenated alkyl chain containing fluorine (fluoroalkylthiophene).

E. V. Murphree, assr to Standard Oil Development Co. U.S.P. 2,515,134, 11.7.50. Describes the separation of butadiene from hydrocarbon gases with cuprous chloride. C. F. S.

CORROSION

1531. Corrosion and its control. M. E. Parker. *Oil Gas J.*, 5.4.51, **49** (48), 106.—Part 7 of this series deals with pipe thickness as related to pipe life. Non-aggressive, average, and corrosion soils are considered. It is concluded that all lines intended to be " permanent " should be coated, otherwise cathodic protection would be costly. Thickness of pipe should be dictated by operating conditions. G. A. C.

1532. Pipe-to-soil potentials as an indication of protection. M. E. Parker. *Oil Gas J.*, 8.3.51, **49** (44), 95.—This is part 5 of a series on corrosion and its control. Correct interpretation of reading of potential at each anode group along a pipeline to obtain reasonably reliable representation of actual potential throughout is discussed. A figure illustrates catenary potential curves. G. A. C.

1533. Internal and external corrosion experience in Shell's products pipelines. S. S. Smith, W. J. Curry, and E. H. Rush. *Corrosion*, 1951, **7** (1), 20.—The first section of the paper summarizes ten years of experience on two product lines using alkaline aqueous solution of sodium nitrite as an internal corrosion inhibitor. Reduction of cost and the short- and long-time effects of nitrite inhibition are illustrated.

The second section describes the use of magnesium anodes to combat corrosion on Shell's products pipeline from Wood River to Chicago. The results of field work and experience gained during five years of work on the line are summarized. The proper field testing and installation of magnesium anodes can control destructive corrosion sufficiently to extend the useful life of uncoated pipelines to about double their unprotected life. J. T.

1534. Report of protective coatings investigation underwater exposure tests, 1941–1949. Summary and conclusions. H. W. Mundt, L. J. Thompson, and S. J. Stacy. *Corrosion*, 1951, **7** (2), 50.—This report and its appendix present the results of inspections and observations of the performance of selected protective coating systems in submerged fresh-water exposure on the Ismuth covering a period of about eight years. The following are the major conclusions: (*a*) The systems showing outstanding performances are those which have been zinc-metallized. (*b*) Zinc metallizing provides a sacrificial prime coat acting as secondary protection if and when the organic topcoats have deteriorated or become damaged. (*c*) Zinc-metallizing is not justified if the length of service is relatively short, *i.e.*, four to five years. (*d*) For priming zinc-metallized surfaces, zinc tetroxychromate pigment in Bakelite resin BR–254, 60% tung oil, 40% linseed oil, 25 gal length vehicle, pigment vehicle ratio 65/35 is best. (*e*) For sandblasted surfaces, zinc dust (80%)–zinc oxide (20%) in the above-mentioned

vehicle is best. (*f*) Protective coatings on metal surfaces from which millscale has not been removed show worst performance. (*g*) The critical value for film thickness appears to be about 4 to 5 mil minimum for a service life minimum of approx five years with the following exceptions: (1) Zinc-metallized specimens which probably have not reached the end of their service; (2) Sandblasted and millscale-intact specimens coated with certain systems which are specified. (*h*) Short-term and/or accelerated tests may be unreliable as long-term performance indicators, and should be used for this purpose only in conjunction with available service records for materials similar to those under study. J. T.

1535. Report of metals corrosion investigation immersion tests five years duration, initiated 1941.—Summary and conclusions. H. W. Mundt, L. J. Thompson, and S. J. Stacy. *Corrosion*, 1951, **7** (2), 51.—The results of field immersion exposures of a selected group of welded and bare uncoupled ferrous and non-ferrous metals in Isthmian fresh, brackish, and sea-waters for durations of one, three, and five years are given in this report and in its Appendix. The following are the major conclusions: (*a*) Exclusive of the welds, stainless steels, and zincs, the rates of corrosion in inches per year (ipy) are rather uniform and fall within relatively narrow-range bands as based on the five-year exposure results for each of the ferrous and non-ferrous groups if considered separately. (*b*) The rates of corrosion of the different grades of uncoupled zinc do not differ significantly if the results for the five-year exposures and all environments are considered. (*c*) Considering the results as a whole, of all the environments tested the continuous brackish water is the most aggressive. (*d*) The non-ferrous metals, excluding zinc, showed better resistance to corrosion in sea-water than in fresh water and least resistance in brackish water. (*e*) The welded sections of the majority of welded specimens exposed in sea-water at mean tide were in good condition after exposure except: copper–nickel structural and copper-bearing steels and nickel.

The spread and average ipy values for the one-year and five-year exposures for the ferrous metals (low alloy steels and wrought iron) are given. J. T.

1536. Studies in galvanic couples. I—Measurement of electromotive force and internal resistance of cells during current flow. II—Some potential-current relations in galvanic corrosion. III—Polarisation and cathodic protection. H. D. Holler. *Corrosion*, 1951, **7** (2), 52–68. J. T.

1537. Flame-sprayed plastic coatings. B. Goldberg. *Corrosion*, 1951, **7** (2), 47.—A brief review of the history of flame spraying is given together with detailed description of guns and powder containers for applying flame-sprayed coatings of plastic powders. Requisite criteria for organic materials both thermosetting and thermoplastic are indicated, and problems involved in producing suitable powders of tough non-friable resins are discussed. Properties of flame-sprayed thiokol coatings are reviewed in some detail. Recent improvements in technique are illustrated by a discussion of advances in flame-spraying of various polyethylene compounds. This ranges from comments on current theory to fuel-gas combinations and polyethylene compounding for obtaining specific properties of sprayed coatings. Data are also given on the effect of after-treatment of flame-sprayed plastic coatings. Experimental work being carried out on fluorinated hydrocarbons is described and a preliminary report on the properties of such coatings is given. Recent developments in the technique for producing smooth non-porous coatings of hot melt compositions is discussed in some detail and the history of several successful applications of flame-sprayed plastic coatings is reviewed. J. T.

1538. Combating corrosion in a chemical plant with magnesium anodes. O. Osborn. *Corrosion*, 1951, **7** (1), 2.—Extensive use of magnesium as a galvanic anode during a four-year period in a large number of chemical-plant applications has shown its excellent properties in combating corrosion and that by suitable mechanical design the magnesium anode can be adapted to a great variety of installations. The maintenance expenditures were reduced from $\frac{1}{2}$ to $\frac{1}{10}$ of their original value on introduction of magnesium anode. J. T.

1539. Water treatment in natural gasoline plants. B. J. Willard and T. C. McCaleb. *Oil Gas J.*, 8.3.51, **39** (44), 78.—Periodic sampling and analysis of all plant waters are

stressed to ensure that treatments are satisfactory. Treatments for control of scale in cooling-tower water after ascertaining reason for scale formation are considered. Algæ growth can be reduced by use of copper sulphate, chlorine, bromine, or copper and sodium pentachlorophenate. Bromine is most effective but hazardous to handle.

Corrosion in open recirculating systems can be mitigated by chemically passivating the metals in the system. Scale formation in closed recirculating systems can be eliminated by use of cooling water which does not contain scale-forming materials.

Boiler-water treatment for scale, foaming, and carryover includes zeolite softening and addition of antifoams composed of polymerized alcohols and esters.

Corrosion in steam-lines can be prevented by treatment which will either neutralize the acidic condensate or passivate the lines by forming a continuous film on the metal.

Raw water used in gasoline plants is usually treated by sodium or hydrogen zeolite softening, or lime–soda softening. Softener control by a rapid colorimetric method is to be preferred to the soap hardness method. G. A. C.

1540. Attenuation curves in cathodic protection. Anon. *Oil Gas J.*, 15.3.51, **49** (45), 85.—Mathematical expressions for the attenuation of current and potential in a long uniform structure with uniform leakage are discussed.

A figure shows attenuation curves on a 4-inch pipeline with excellent coating.

G. A. C.

1541. Controlling scale in cooling towers without increasing water use. M. A. Enquist. *Oil Gas J.*, 15.3.51, **49** (45), 88.—A method is described of controlling scale formation, which reduces the water comsumption of a cooling tower to that required for cooling plus drift.

Water is fed through a contacting mineral bed which filters out suspended and other organic matter which contribute to the volume of scale.

Test results and a water analysis of jacket-water cooling tower are tabulated.

The system reduced corrosion rate from 100 to less than 10 mg/sq. dm/day.

G. A. C.

1542. Patents. L. G. Nunn, assr to Standard Oil Development Co. U.S.P. 2,514,508, 11.7.50. The prevention of corrosion of ferrous metals in contact with fluids containing H_2S, by adding to the fluid a urea formaldehyde condensation product.

R. F. Drysdale and R. W. Parker, assrs to The Walterisation Co. Ltd., England. U.S.P. 2,514,941, 11.7.50. A process for increasing the corrosion-resistance of metals where the coating composition contains an aqueous solution of a metal phosphate and phosphoric acid and a small amount of anhydrous zinc ammonium phosphate.

C. F. S.

Engines and Automotive Equipment

1543. Automobile petrol engines. D. Bastow. *Auto Engr*, Apr. 1951, **41** (539), 153.—A detailed consideration of the factors affecting the performance of an engine. Included in this examination are studies of friction loss variation due to crankshaft speed and piston speed, variation of i.m.e.p. with cylinder bore and compression ratio, variation of compression ratio with bore. At the same time the effect on the power output of automobile engines of head design, O.N., and specific weight is considered. A large amount of past experience on this subject is quoted. Particulars are given of typical engines operating on (*a*) 70-octane fuel, (*b*) 80-octane fuel, and in each case details are given of engines which have side valves, in-line overhead valves, hemispherical head, and a bore/stroke ratio of 0·70 : 1, and an engine with hemispherical head and a stroke of 2·66 inches. Attainable specific fuel consumptions are based on octane fuel, the max-torque speed, and 120% correct mixture strength. It is assumed that the heat losses given by David and Leah (1940) for a compact combustion chamber apply in each case. Values of the fuel consumption in miles per gal are based on these full-throttle specific-consumption figures. A. S.

1544. Oil engine problems and achievements. J. J. Broeze. *I.P. Review*, Feb. 1951, **5** (50), 33.—The development of the oil-engine proceeded slowly in the early stages, owing to the late development of engine chemistry. However, since 1930, the oil

industry has started to study the behaviour of products when used by the customer in various types of engine. The main problems encountered in marine engines, particularly in two-stroke engines, are possibly piston and cyl wear at high temp. It is said that there is a direct correlation between these properties and the sulphur content of the fuel employed. This and other related problems are discussed In the case of transport, multiple-engine systems are often employed to safeguard against the breakdown of a single engine. In general, the diesel engine is well qualified to take its place in the picture of power. It is still at the top of the list for thermal efficiency, and is flexible in its choice of fuel. R. H.

1545. Nozzle reconditioning. Anon. *Auto Engr*, Apr. 1951, **41** (539), 135.—Many road-transport vehicles powered by diesel engines operate at much less than optimum efficiency because of the failure to carry out periodic examination and reconditioning of the injector nozzles. An injector nozzle is a precision component which has to operate under extremely onerous conditions so that under these conditions wear and the consequent loss of efficiency are inevitable. However, regular servicing and reconditioning enable the injector to be restored almost to its original condition. In these days there is available a relatively inexpensive equipment specially developed to allow nozzle reconditioning to be carried out in a logical and practical manner. The equipment described is that produced by Leslie Hartridge Ltd., and this includes a simple form of dismantling and assembly jig suitable for all types of injector nozzles, an inspection microscope, a grinding and lapping machine for the purpose of reconditioning, a cleaning cabinet, and a nozzle-testing machine. These various parts of the equipment are described and illustrated, and it is emphasized that this range of equipment is an important factor in the maintenance of diesel-vehicle operating efficiency. A. S.

1546. Simple cold-starting device for diesel engines. Anon. *Gas Oil Pwr*, 1951, **46**, 40–2.—Suitable for use at temp down to 0° F, this device screws into the inlet manifold and provides for the automatic injection of ether into the engine in two stages: (1) as a rich mixture to obtain a first ignition, and (2) as a weak mixture to maintain ignition until the combustion-chamber temp is raised sufficiently for running on normal fuel.

The operation of the device is described in detail. The starting sequence is not under the operator's control, and is claimed to be foolproof. In a demonstration an engine at −12° C was started within a few seconds. H. C. E.

1547. New Ruston product. Anon. *Gas Oil Pwr*, 1951, **46**, 62–4.—The motive power of this mine locomotive is supplied by a Ruston 4YEL vertical four-cyl four-stroke diesel with a 12-hr rating of 75 b.h.p. and speed range 500 to 1500 r.p.m. Power is transmitted through a fluid coupling to a four-speed gear-box.

Details of the locomotive construction, its auxiliaries, and equipment are given. In working order it weighs 10 tons. A table is given of haulage capacities at various speeds. H. C. E.

1548. Uniporn vertical range [of diesel engines]. Anon. *Gas Oil Pwr*, 1951, **46**, 43.—These engines have from one to four cyl of dimensions 125 mm bore and 180 mm stroke, with a rated output of 15 to 17 b.h.p. per cyl at 1000 to 1100 r.p.m. The b.m.e.p. at full load is 88 p.s.i. The combustion chamber is of the open type, and two valves are provided. The cyl are of cast iron, and the pistons of Al alloy having four compression and one scraper ring.

Pressure lubrication is by means of a gear-type pump. The specific fuel consumption is 0·42 lb/b.h.p.hr at full load. H. C. E.

1549. Versatile American two-stroke [diesel engines]. Anon. *Gas Oil Pwr*, 1951, **46**, 66–8.—These engines are constructed in three different cylinder sizes: of bore and stroke 6½ by 9 inches, 8½ by 11½ inches and 18 by 27 inches respectively. They operate at 720, 514, and 277 r.p.m. respectively. The two smaller units are available with from five to eight cyl giving a power range from 175 to 480 b.h.p., and the largest unit has six, eight, or ten cyl with a power range from 2100 to 3500 b.h.p. All are loop-scavenged two-stroke engines and are fitted for operation on gas as well as oil fuel.

Details of the engine construction are given. All parts are pressure-lubricated, and piston cooling is accomplished by forcing oil through the drilled connecting-rod to the

piston crown, whence it circulates inside the piston and returns to the sump. Reversal of the engine does not affect the operation of the scavenging pump, which is of the oscillating type.

Under gas operation ignition is accomplished by a small pilot injection of fuel oil, which is constant under all load conditions, and the amount of gas is controlled by the pressure in the storage tank, this pressure being controlled by the governor. Transition from gas to fuel oil or vice versa is made automatically, depending on the supply of gas.

H. C. E.

1550. New range of power packs. Anon. *Gas Oil Pwr*, 1951, **46**, 38–9.—These Russell Newberry sets cover a power range from 7 to 120 b.h.p. gross. The D and DX types have from one to four cyl of bore 4½ inches and stroke 6 inches. The PD4 engine has four cyl of bore 4⅜ inches and stroke 6 inches. The D and DX types operate at 1200 and 1500 r.p.m. respectively, and give a range from 7 to 58 b.h.p. Performance curves are given as a plot of b.h.p. against r.p.m. In these engines the clerestory-type combustion chamber is offset and the valves are positioned horizontally. During the compression stroke the air is given a rapid swirl, and at the moment of injection a controlled turbulence is created.

The E series of engines have three, four, or six cyl of bore 5½ inches and stroke 7½ inches. The max output is 130 b.h.p. at 1200 r.p.m., and the rated b.m.e.p. is 80 p.s.i.

H. C. E.

1551. Pescara free-piston gas generator. A. C. Hardy. *Gas Oil Pwr*, 1951, **46**, 34–7.—The free-piston gas generator has a low fuel consumption and is almost free of vibration. The GS34 type has a working cylinder dia of 340 mm and stroke of 2 × 250 mm, and is rated at 1100 b.h.p. The unit comprises two opposed pistons working in the same cyl, and each is fitted at its outer end with a piston of 900 mm dia working in a compressor cyl. Starting at inner dead centre, all the energy developed by the combustion gases is accumulated in pneumatic springs. On the outward stroke the working cyl is first exhausted, then scavenged, and finally supercharged. The energy in the pneumatic springs then returns the pistons, which compress the air for a future charge, and also compress the gas in the working cyl, which is equipped with five fuel injectors spaced round the circumference. The gas discharged from the exhaust port, at pressure 3 to 3·5 kg/cm² and temp 450° to 500° C, is led to a gas turbine operating at 6000 to 11,000 r.p.m.

Starting is accomplished by compressed air. The usual pumps and heat exchangers are required for the water- and oil-cooling systems. The power pistons are cooled by oil delivered through telescopic stand pipes. As used at present, the GS34 generator occupies a space of 4·15 m length and 1·2 m dia, and weighs 8·5 tonnes. The machine is readily dismantled, and the comparatively low temp of the exhaust gas means that there are no difficulties connected with the gas turbine, which is in this respect comparable to a superheated steam unit.

H. C. E.

1552. Sulzer semiclosed gas turbine. Anon. *Gas Oil Pwr*, 1951, **46**, 58–60.—A comparison is made between the open-cycle and closed-cycle systems as applied to a gas turbine. The closed cycle has the advantages of working at high pressure, and permits a wider range of fuels to be used. On the other hand, the weight and space requirements of the two systems are not very different, and hence for marine work the semi-closed cycle is to be preferred.

A detailed description of a semi-closed cycle system is given. The closed circuit consists of a compressor A, which raises the air pressure from 70 to 280 p.s.i., and after heating the air is expanded in a turbine which drives A. A handles in addition air on an open cycle. The closed-cycle heater utilizes this air, which is then expanded in turbine B, which drives the compressor supplying the additional air required for the open circuit; and the open-cycle air, after reheating, passes through the low-pressure work turbine C before venting to the atmosphere at 14 p.s.i. The advantages of this system are discussed in terms of size of components and efficiency of working.

Two plants working on this system are now in operation. The first, built in 1947, has an output of 7000 s.h.p. and attains an efficiency of *ca* 30% at a max temp of 1200° F at the turbine inlet. The second, built in 1949–50, has an output of 20,000 kW and is used for generating electricity. This unit burns heavy fuel oil, which is heated to 200° F before injection.

H. C. E.

1553. Dutch gas turbine progress. Anon. *Gas Oil Pwr*, 1951, **46**, 64.—A 2000-kW gas-turbine generator set is now being built for the B.P.M. Co. for a refinery in Venezuela. Designed to run on waste refinery gases, the machine is of the open-circuit type without heat exchanger or regenerator. Long periods of continuous operation are required, and the max gas temp at the turbine inlet will therefore not exceed 600° C. H. C. E.

1554. Combustion problems of the gas turbine. I. Lubbock. *Trans. North East Coast. Inst. Engrs and Shipbuilders*, 1951, **67**, 131–54; D 35–44.—The complexities of the problems associated with combustion are examined with regard to the contributory effects of grade of fuel consumed, atomization of the fuel, combustion air distribution, and airflow pattern. Their effect on the burner and combustion chamber of a gas turbine is discussed from the point of view of the designer. Existing designs are used for illustration. Emphasis is on combustion systems for the burning of heavy grades of fuel in industrial and marine units, and comparative reference is made to the problems encountered in aircraft units. Finally, specialized problems, such as ash formation are summarized and present approaches towards their solution are dealt with. (Author's summary.)

1555. Running experience with the Ruston and Hornsby gas turbine. Anon. *Mech. World*, 13.4.51, **129** (3352), 333.—A 750-h.p. gas turbine manufactured by Ruston and Hornsby Ltd, is the first prototype of a production industrial gas turbine. This machine was described in *Mech. World* 26.8.49. Throughout the testing the "outage" of the set was due to relatively minor items rather than failures of major components. During the eighteen months since the plant was first run the set has been shut down on only one occasion due to a defect in the heat exchanger. During that time there have been no shut-downs due to defects in the compressor or turbines. Most of the lost running time has been due to troubles with the fuel atomizers, but the introduction of specially designed "Shell" fuel-cooled atomizers has completely eliminated the troubles from this source. Generally speaking it can now be stated with reasonable confidence that little trouble in this unit is to be expected from the two basically new elements in the gas turbine—namely the compressor and the high-temp turbine. In future the large-scale utilization of gas turbines will depend on their ability to run on residual oil fuels and upon solid fuels. Encouraging progress on this aspect is being made. One opinion is that a gradual change-over to gas-turbine power-plant will take place in some section of the industrial field during the next fifteen years. Eventually it is expected that when methods of blade-cooling have been fully developed gas-turbine efficiencies will exceed those of present-day diesel engines. The paper gives a description of some of the troubles experienced during the first 1100 hr running of the above plant, and special reference is made to the combustion system, the turbines, and the reduction gear. A. S.

Safety Precautions

1556. Fire hazards and precautions in the petroleum industry. E. E. Chanter. *Petroleum*, Dec. 1950, **13** (12), 314–18.—(*Paper given at Assoc of British Chemical Manufacturer's Chemical Works Safety Conf. in Scarborough, Oct.* 1, 1950.)—Parallel to the tremendous development which has taken place in the petroleum industry corresponding progress has been made in fire prevention and protection. The author reviews causes, major fire hazards, and precautions taken. The major fire hazards are, naked lights, static electricity (especially in pumping), electrical sparks, gas firing, and gas pockets. Main precautions are to eliminate fire risk by sound engineering, regular inspection of the plant, special training of the plant personnel, the provision of steam snuffing facilities at all danger points, and provision of portable foam, carbon dioxide, and other chemical-type extinguishers.

The basis of fire extinction is the elimination of one or more of the three conditions, viz., fuel, oxygen, and heat, which must exist simultaneously for the promotion of fire. Types of foam and foam equipment used to blanket the burning oil surface are described, and the limited application of water emphasized. R. E. P.

1557. Erection and mode of operation of Europe's largest air-foam installation for petroleum tank protection. D. K. Möbius and F. Emmrich. *Erdöl u. Kohle*, 1951, **4**, 126–30.—Illustrated description of permanent fire-protection installation at Gelsenkirchen. Total capacity is 42·5 m^3 H_2O (275 m^3 foam)/min; two mixing centres protect thirty tanks (dia up to 56 m) having area of 13,800 m^2 and capacity of 138,000 m^3. In addition, 23,000 m^2 of tank farms, ditches, pipe trenches, etc., can be foam-covered. Design capacity is a foam layer of 125 cm within 15 min on the largest tank. Foaming agent (not specified) required is 3·5% on water, operating pressure is 5 atm. V. B.

1558. Treatment of hydrofluoric acid burns. R. H. Dale. *Brit. Med. J.*, 1951, i, 728–32, cf. *ibid.*, 750 (editorial).—Literature of HF burns is reviewed and treatment discussed. Latter is based on dilution and neutralization of acid and pptn as insol fluoride. Recommended procedure is immediate washing or immersion in warm $NaHCO_3$ followed by application of MgO/glycero cream and injection (under anæsthesia if necessary) of 10% Ca gluconate beneath burn coagulum. Detailed illustrated case report is given of hand burns caused by 60% aq HF. Extent of destruction latent beneath apparently superficial lesion is emphasized. V. B.

1559. Safety training by specific practice problems. Part 6. Derrick structure practice. J. I. Powell. *World Oil*, Sept. 1950, **131** (4), 152–60.—Of the 700 accidents examined, forty-three occurred above the derrick floor, these including two fatalities. The question of riding the elevators or climbing the ladder to or from the monkey board is discussed. Where "riding the elevators," is allowed it is recommended that a safety landing line be affixed to the derrick in a suitable position. The derrickman could then snap a hook on his belt line to this safety line before jumping the gap to the monkey board. A. H.

Miscellaneous

1560. North American operating refineries. Anon. *Oil Gas J.*, 29.3.51, **49** (47), 330.—North American (including Canadian and Mexican) refineries are listed, giving locations, capacities, and types of processes used.
Plants shut-down are also shown. G. A. C.

1561. Sharp upward trend in refinery construction. R. B. Tuttle. *Oil Gas J.*, 29.3.51, **49** (47), 343.—Active refinery building projects in the U.S.A. are listed, showing capacity rating, status (planned, building, or contracted), completion schedule, and contractors. Projects involving improved gasoline manufacture head the list. G. A. C.

1562. Changing patterns of fuel supply. J. Boyd. *Mech. Engng*, Mar. 1951, **75** (3), 189.—In the U.S.A. coal provided the greatest portion of the total energy supply in 1920, but since then the increase in total requirements has been provided almost entirely by petroleum, natural gas, and water-power. The proportion of total fuel needs provided by coal declined from over 78% in 1920 to less than 40% in 1949, while the share of petroleum increased in the same period from 15% to nearly 37%, and that of natural gas from 4% to over 19%. The construction of long-distance pipelines has increased the use of natural gas, and liquefied petroleum gases are now a major petroleum product. The demands for light fuel oils have been stepped up by the rapid expansion in the use of diesel engines for rail and road transport, construction work, and farm equipment. The installation of considerable quantities of space-heating equipment and plant for generating electricity has resulted in the use of larger quantities of fuel oil. The largest amount of petroleum is still consumed by 44 million motor vehicles. It is expected that in the future the synthesis of liquid and gaseous fuels will become more important because it is estimated that petroleum production in the U.S. will reach its peak between 1955 and 1960, and that by 1967 production will have fallen by 50%. The anticipated gap widening between domestic demand and supply will have to be met by synthetic liquid fuels and imports. The liquid-fuels position will be much more secure when supply is based in part upon solid fuels such as coal and oil shale, since these constitute more than 95% of the proved fuel reserves. A. S.

1563. French petroleum industry in 1950. R. André. *Chim. et Ind.*, 1951, **65**, 105–7.—A summary of a report; touching briefly on prospecting, transport, refining, distribution, and importation. Latter is now practically confined to crude pet (1949 figures being 11·5 million tons crude as against 423,000 tons of refined products). V. B.

1564. Italian petroleum chemistry problems. G. Pastonesi. *Riv. Comb.*, **5** (2), 115–22. (*National Chemistry Congress, Milan, Sept.* 17–23, 1950.)—Possible developments of petrochemical industry in Italy are discussed by the author, with particular regard to the problem of raw material and of finished products in connexion with economic conditions of Italian market.

Conclusion is rather negative as to the possibility of a future development of petrochemical industry in Italy. (Author's abstract.)

1565. Adequate protection now of strategic oil supplies urged. G. Egloff. *Refiner*, 1950, **29** (12), 104–6.—Figures are given for production of crude oil by the various world areas in July 1950, land oil reserves, and European refining capacities. Total world crude oil production in July 1950 was some 10 million b.d. Estimated land reserves stand at 600 billion brl with 1000 billion brl reserved under continental shelves. The refining capacity for Europe is recommended by ECA to show an increase in 1953 of some two and a half times over that of 1949, bringing the total up to 1,258,300 b.d. It is pointed out that the Middle East provides a large source of petroleum, which is almost only used by Western Europe, and that this source should be protected. R. W. G.

1566. Fuels and lubricants needs listed by army (U.S.). B. S. Merrick. *Refiner*, 1950, **29** (12), 88–92. (*A.P.I. Mtng, Los Angeles*, Nov. 1950.)—The present need for the standardization of fuels and other petroleum products used by the military is emphasized. Products are desired to be suitable simultaneously under high- and low-temperature conditions in all standard units. The Co-ordinating Research Council, Inc., is assisting in co-ordinating the petroleum industry's and equipment manufacturer's research towards the military requirements. The characteristics or properties of fuels and lubricants in general which need further improvement to meet military requirements are storage and oxidation stability. R. W. G.

1567. Pipeline construction. S. Lillie. *World Oil*, Sept. 1950, **131** (4), 251–2.—Projects announced, starting, and completed are listed. A. H.

1568. Permian basin pipelines transport 1 million barrels daily. C. W. Smith. *World Oil*, Sept. 1950, **131** (4), 235–6.—In 1944 total daily capacity of the eleven trunk lines amounted to only 538,000 brl. Now there are fifteen lines capable of hauling 1,174,300 brl of crude a day, and there are indications that this still will not be enough. The trunk lines to and from West Texas are listed, showing size and capacity and illustrated on a map. Permian basin refineries are also listed. A. H.

1569. Staff promotion schemes. J. Ballet. *Bull. Ass. franç. Tech. Pétrole*, 1951 (85), 21–53.—General discussion, with particular reference to the policy and procedure adopted by the Standard Française. Illustrated by charts showing executive organization and staff record system. Average staff age is forty-three, with seventeen years seniority. V. B.

1570. Experimental oil-well. H. Gorka. *Nafta*, Dec. 1949, **5**, 359–62.—The (Polish) Institute of Petroleum took over in Jan. 1949 a small well to conduct a series of experiments of general nature and to train men for the industry and colleges.

New equipment is tested there, planning is conducted and carried out, standardization of equipment and methods, efficiency, economy, and exploitation tests are made.

Summary of achievements over twelve months is briefly given. M.S.

1571. Selection testing in petroleum industry. E. Turska. *Nafta*, Dec. 1949, **5**, 379–81.—Summary of results obtained from ability and intelligence tests on a group of young scholars of two secondary technical schools under the care of (Polish) Petroleum Institute. There were 58% of scholars receiving the right kind of training, of whom about one-sixth should go on to higher schools, 6% of scholars also would have done better at a different school, and 35% of scholars unsuited to any advanced training. M. S.

ADDITIONS TO THE LIBRARY

Distillation Equilibrium Data. Ju Chin Chu. New York: Reinhold Publishing Corpn. London: Chapman & Hall, 1950. Pp. 304 + 5. 48*s*.

Vapour–liquid equilibrium data are presented for 176 systems, of which 145 are binary, twenty-six are ternary, and the remainder multiple component. To facilitate reference, the components are referred to by their common names as well as their chemical formula, and a formula index is provided to enable a particular system to be located.

In each case the original source of the data is indicated, and the bibliography appended contains 107 entries.

This book provides a ready-reference volume for the chemical engineer, the research worker, and the student. The author is Associate Professor of chemical engineering at the Polytechnic Institute of Brooklyn.

British Standards. British Standards Institution, London.

B.S. 1730: 1951. Seamless low carbon and carbon-molybdenum steel furnace tubes for the petroleum industry. Pp. 11. 2*s*. net, post free.

B.S. 1731: 1951. Seamless alloy steel furnace tubes for the petroleum industry. Pp. 10. 2*s*. net, post free.

B.S. 1733: 1951. Flow cups and their method of use (for consistency control of paints and varnishes). Pp. 9. 2*s*. net, post free.

B.S. 1347: Part 2: 1951. Boxwood scales. Part 2: Scales for quantity surveyors. Pp. 7 + 2 diagrams. 2*s*. net, post free.

B.S. 1083: 1951. Precision hexagon bolts, nuts (B.S.W. and B.S.F. threads) and plain washers. Pp. 35. 4*s*. net, post free.

B.S. 641: 1951. Dimensions of small rivets for general purposes. Pp. 18. 2*s*. 6*d*. net, post free.

B.S. 1710: 1951. Colour identification of pipelines. Pp. 13. 2*s*. 6*d*. net, post free.

B.S. 1726: 1951. Guide to method of the specifying helical compression springs. Pp. 37. 4*s*. net, post free.

B.S. 1734: 1951. Micrometer heads. Pp. 12. 2*s*. net, post free.

B.S. 329: 1951. Round strand steel wire suspension ropes for lifts and hoists. Pp. 27. 3*s*. net, post free.

B.S. 57: 1951. B.A. screws, bolts, nuts and plain washers. Pp. 28. 3*s*. net, post free.

Laboratory Fractional Distillation. T. P. Carney. New York: The Macmillan Co., 1949. Pp. viii + 259. $5.75.

APPLICATIONS FOR MEMBERSHIP OR TRANSFER

JUNE 1951

The following have applied for admission to or transfer of membership in the Institute. In accordance with the By-laws, the proposals will not be considered until the lapse of at least one month after the publication of this *Journal*, during which time any Fellow, Member, Associate Fellow, or Associate Member may communicate by letter to the Secretary, for the confidential information of the Council, any particulars he may possess respecting the qualifications or suitability of the candidate.

The object of this information is to assist the Council in grading the candidate according to the class of membership.

The names of candidates' proposers and seconders are given in parentheses.

Application for Membership

ACTON, William Samuel, shift controller, Kuwait Oil Co. Ltd. (*E. Boaden ; J. D. Johnson.*)

BABINGTON, Anthony Macauley, junior petroleum engineer, Kuwait Oil Co. Ltd. (*E. Boaden ; R. M. S. Owen.*)

BRAHAM, John Robert, project engineer, Messrs. Ewbank & Partners Ltd. (*C. E. R. Sams ; G. Sell.*)

BRAY, Francis Henry, assistant manager, Gulf Oil (G.B.) Ltd. (*T. J. Metcalf ; D. E. McAlpine.*)

BUIE, William C., chief petroleum engineer, Kuwait Oil Co. Ltd. (*E. Boaden ; R. M. S. Owen.*)

CALDWELL, Arthur Bellian, shift controller, Kuwait Oil Co. Ltd. (*E. Boaden ; J. D. Johnson.*)

CARPENTER, Alexander, shift control operator, Kuwait Oil Co. Ltd. (*E. Boaden ; V. J. Chir.*)

CRUTCHLEIGH-FITZPATRICK, Denis Patrick, assistant personnel officer, Kuwait Oil Co. Ltd. (*E. Boaden ; R. M. S. Owen.*)

de PAIVA, Geraldo Augusto, lubrication engineer, Brazilian National Steel Co.

EAST, Frederick, plant engineer, Kuwait Oil Co. Ltd. (*E. Boaden ; R. M. S. Owen.*)

EVANS, Aneurin, personnel officer, Kuwait Oil Co. Ltd. (*E. Boaden ; R. M. S. Owen.*)

FORREST, Robert, assistant manager, Shell-Mex & B.P. Ltd. (*A. H. Stephenson ; C. A. A. Rogerson.*)

GANLEY, Alexander Wilfred, section head, Engineering Division, Anglo-Iranian Oil Co. Ltd. (*G. E. Wheeler ; R. E. Adlington.*)

HALL, Arthur Edward, representative, Messrs. Kenneth Thelwall Ltd. (*R. Todd ; G. Sell.*)

HARDIE, David John, chemical engineer, Anglo-Iranian Oil Co. Ltd. (*S. W. Adey ; E. H. Ettlinger.*)

JOHN, Rhys Morgan Madoc, topping plant operator, Kuwait Oil Co. Ltd. (*E. Boaden ; V. J. Chir.*)

KYNASTON, Alan Henry, senior assistant engineer, Messrs. Alexander Duckham & Co. Ltd. (*J. S. Jackson ; G. O. Joyce.*)

LEGG, Harold Walter Lovell, manager, Dealer Sales Dept., Esso Petroleum Co. Ltd. (*C. Chilvers ; H. C. Tett.*)

LEWIS, Thomas Pearson, assistant driller, Kuwait Oil Co. Ltd. (*E. Boaden ; R. M. S. Owen.*)

MACDONALD, John Morrison, shift control operator, Kuwait Oil Co. Ltd. (*E. Boaden ; J. D. Johnson.*)

NORRIS, Alfred Charles, progress engineer, Messrs. E. B. Badger & Sons (G.B.) Ltd. (*J. T. T. Robinson ; C. J. Paysant.*)

PICKARD, Ronald James, topping plant operator, Kuwait Oil Co. Ltd. (*E. Boaden ; V. J. Chir.*)

PITTS, David John Francis, shift control operator, Kuwait Oil Co. Ltd. (*E. Boaden ; J. D. Johnson.*)

RAE, John, production supervisor, Kuwait Oil Co. Ltd. (*E. Boaden ; J. D. Johnson.*)

RENTON, Walter C. (Jr.), petroleum engineer, Kuwait Oil Co. Ltd. (*E. Boaden ; R. M. S. Owen.*)

ROBINSON, John Harold, instrument engineer, Kuwait Oil Co. Ltd. (*E. Boaden ; J. D Johnson.*)
ST. KONSTAS, Anastasius, technical adviser to Greek Government (Chemical Industry).
SAMSON, Victor Frederick Henry, assistant engineer, Anglo-Iranian Oil Co. Ltd. (*G. E. Wheeler ; R. E. Adlington.*)
SCHULTZE, Otto Richard George, professor, Technical University, Hannover, Germany. (*L. Ubbelhode.*)
SMALLWOOD, Richard Alfred, shift control operator, Kuwait Oil Co. Ltd. (*E. Boaden ; J. D. Johnson.*)
SMITH, Alfred William Gilbody, superviser (Drilling & Production Stores), Kuwait Oil Co. Ltd. (*E. Boaden ; J. D. Johnson.*)
STEWART, Horace Angus, in charge Budget Division, Kuwait Oil Co. Ltd. (*C. S. Cleverley ; L. D. Scott.*)
SYRENGHELAS, George Ch., director, Elbyn Lubricating Oil Refinery Ltd.
THOMAS, William Idris, shift production operator, Kuwait Oil Co. Ltd. (*E. Boaden ; J. D. Johnson.*)
TRIST, Maxwell Browse Fincher, chief drilling superintendent, Anglo-Iranian Oil Co. Ltd. (*H. Macniven ; W. J. Baker.*)
TURNER, Kenneth, chief chemist, Kuwait Oil Co. Ltd. (*E. Boaden ; V. J. Chir.*)
WATSON, Thomas William, production supervisor, Kuwait Oil Co. Ltd. (*E. Boaden ; R. M. S. Owen.*)
WILBY, Peter Thomas, technical sales engineer, Simplex Electric Co. (*H. S. Allpress.*)
WILLIAMSON, David Lessels, chemist, Scottish Oils Ltd. (*H. B. Nisbet ; D. T. Rigden.*)
WOOD, James Herbert, divisional chief analyst, National Coal Board (N.W.). (*W. Roman ; W. M. Huggett.*)

Transfers

MARTIN, Richard Ernest, petroleum engineer, Kuwait Oil Co. Ltd. (*E. Boaden ; R. M. S. Owen.*) (*Student to Associate Fellow.*)
MOCKFORD, Dennis James, exploitation engineer, N.V. de Bataafsche Petroleum Mij. (*Student.*)
STOUT, Kenneth Rowland, exploitation engineer, Shell Oil Company. (*Student to Associate Fellow.*)

NEW MEMBERS

The following elections have been made by the Council in accordance with the By-laws.

Elections are subject to confirmation in accordance with the By-laws.

As Fellows

COOPER, J. M. PARK, G. M.

As Members

ECKER, H. PRICE, A. E.
NEWLYN, H. D.

As Associate Fellows

BOYD, J. W. LENNIE, K. S.
CLARKE, A. H. WANKLYN, P. R.
DICKINS, G. A. WARD, J. M.
HENNING, J.

Transferred from Students to Associate Fellows

CULLINGHAM, E. K. WETHERELL, K.
EDGHILL, C. M. WILLMOTT, I. A.

As Associate Members

CURTIS, D. S. NEWBERY, G. B.
JEENS, K. P. H. TAYLOR, A. H.
LONG, K. J. THORPE, R. C.

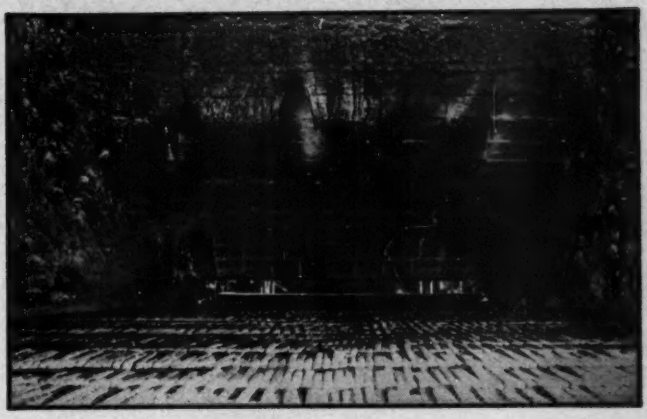
Transferred from Student to Associate Member

HANCHARD, K. W.

As Student

MARTIN, G.

STEIN *Refractories*



For long and reliable service under arduous conditions "Nettle" and "Thistle" Firebricks are widely renowned.

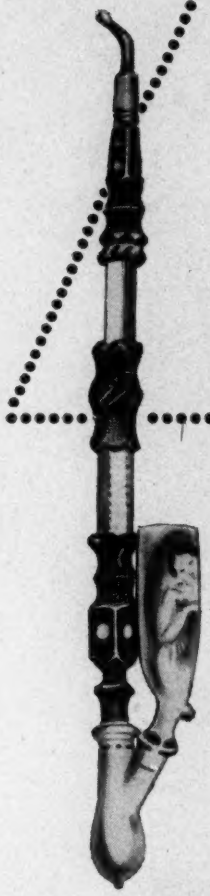
Made from selected fireclays by most modern methods under constant laboratory control "Nettle" and "Thistle" have set a standard for consistency of quality.

Full particulars of our Firebrick Brands, Refractory Cements, Castables and Concretes will be gladly sent on request.

JOHN G. STEIN & Co LTD Bonnybridge. Scotland

NUMBER SEVEN

TALKING OF PIPES



from "The Pipe Book"
by Alfred Dunhill

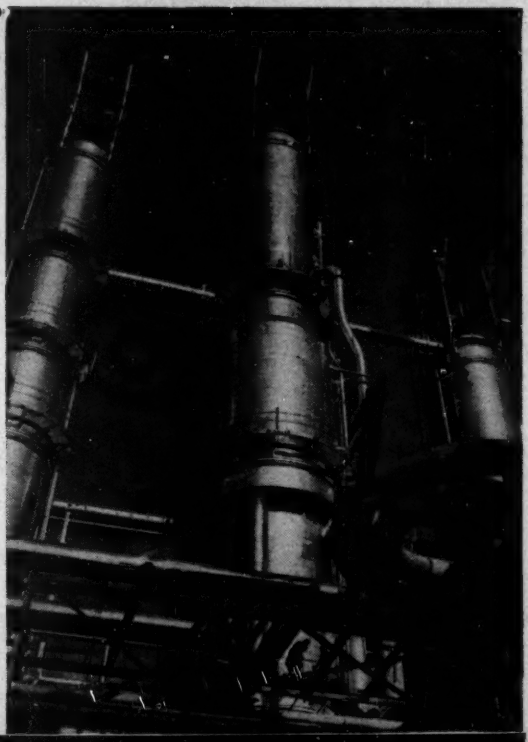
GERMAN PORCELAIN PIPE

The typical Central European pipe of today can be traced to the eighteenth century Dutch clay. The stem is, however, broken short and the bowl is inserted into a holder or base. By this arrangement, both bowl and stem are upright and the deleterious tobacco juices drain down into the holder. Such a pipe is capable of infinite variations in decoration.

INDUSTRIAL PIPING AND ITS HEAT INSULATION

Kenyon make a speciality of furnishing and applying heat insulation for oil refineries and petroleum chemical plants throughout the world. A complete service is offered including technical guidance and supervision on site at all stages of erection and production. Our engineers are available for consultation at all times.

WILLIAM KENYON & SONS LIMITED
DUKINFIELD - - - CHESHIRE



"A Shell Photograph"

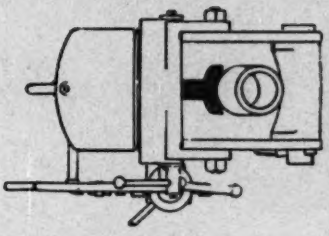
KENYON *Planned* HEAT INSULATION

KH 117

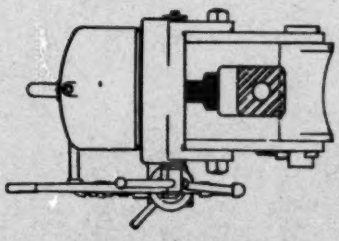
BENT KELLYS AND DRILL PIPE ARE HAZARDOUS AND EXPENSIVE

IT is a SAFE, SIMPLE and INEXPENSIVE operation to take the kinks and bends out of Kellys and drill pipe when they are hanging in a normal VERTICAL POSITION in the derrick.

Probably more Kellys are bent in being laid down, picked up, and during transportation, than from any other cause. Frequently a Kelly that has just been straightened in a shop will again be bent during the process of transporting it back to the well, rolling it off the truck, and dragging it into the rig.



Easily adapted for straightening pipe.



Set-up for straightening Kelly.

EASY TO STRAIGHTEN IN THE DERRICK

When the Baker Kelly Straightener is used, the job is done RIGHT ON THE ROTARY TABLE, with the Kelly hanging in its normal position. In foreign or isolated fields the Baker Kelly Straightener is considered indispensible, as the cost and the loss of time in transporting a bent Kelly or drill pipe to and from a distant shop are serious matters.

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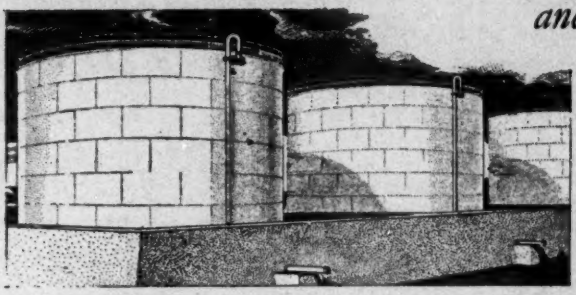

The production and processing of oil in all its various phases involves many different fire dangers, all of which can be successfully overcome with one or the other of "Pyrene" Fire Appliances. Some of the latest forms are shown here, including a "Pyrene" Foam Tender, fixed Foam Installations, "Pyrene" Portable Foam Tower and the P.D. 20 Extinguisher. Amongst other notable "Pyrene" Equipment for fighting oil and spirit fires are Mechanical Foam Generators and Foam-making Branchpipes. Those responsible for fire safety in the Oil Industry may benefit by the experience and research of our Engineers and Chemists who will be pleased to give free and impartial advice on these fire problems.

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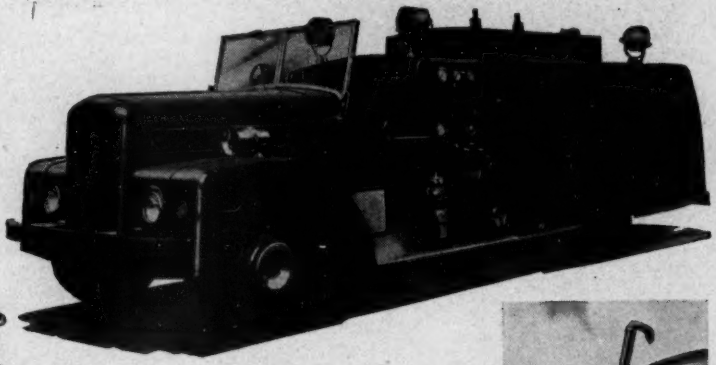

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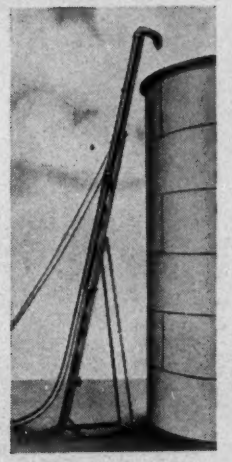

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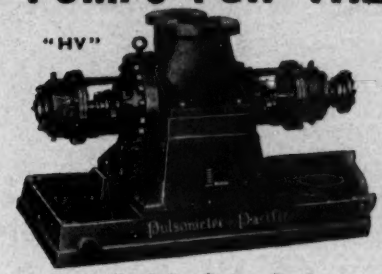

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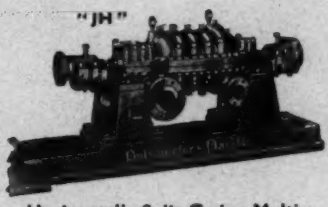

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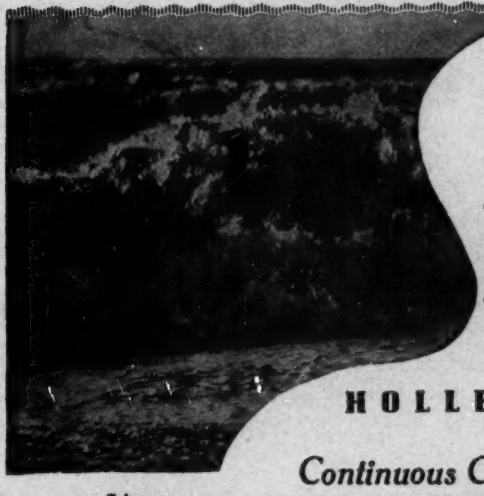

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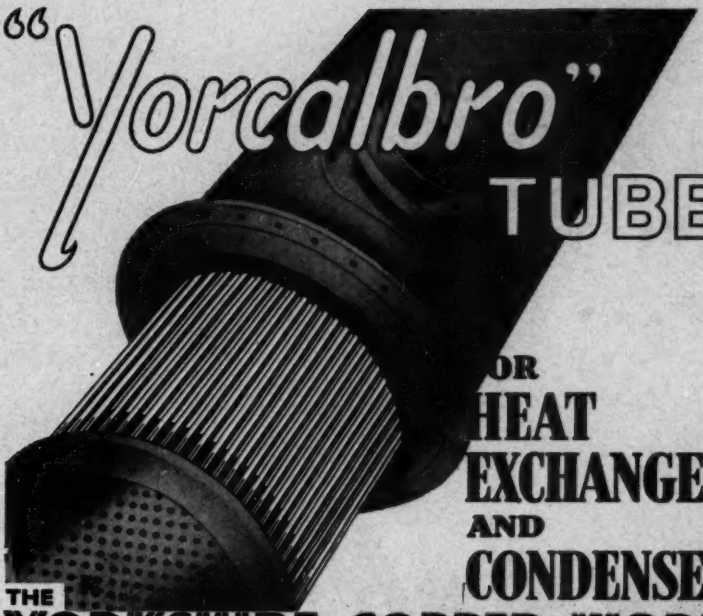

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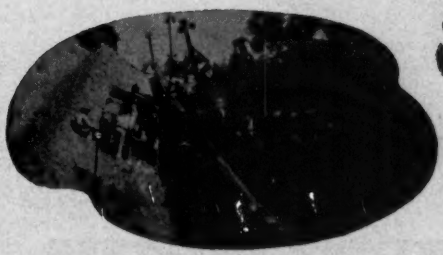

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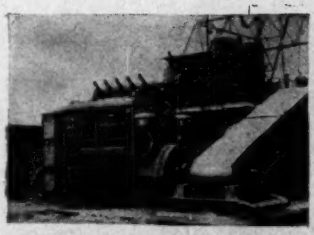

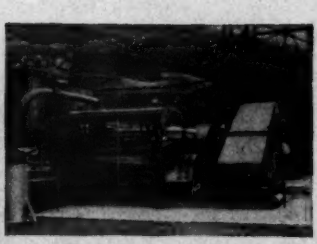

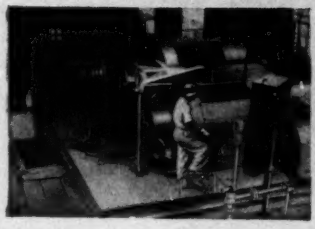

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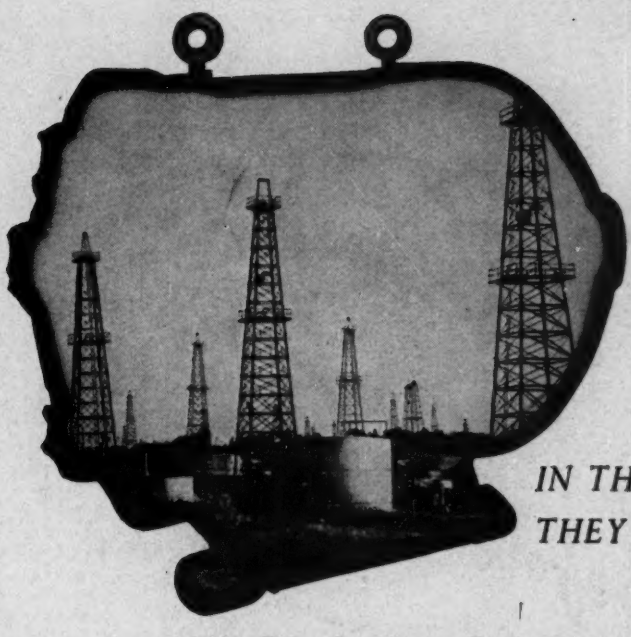

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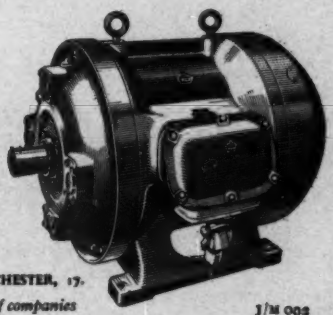

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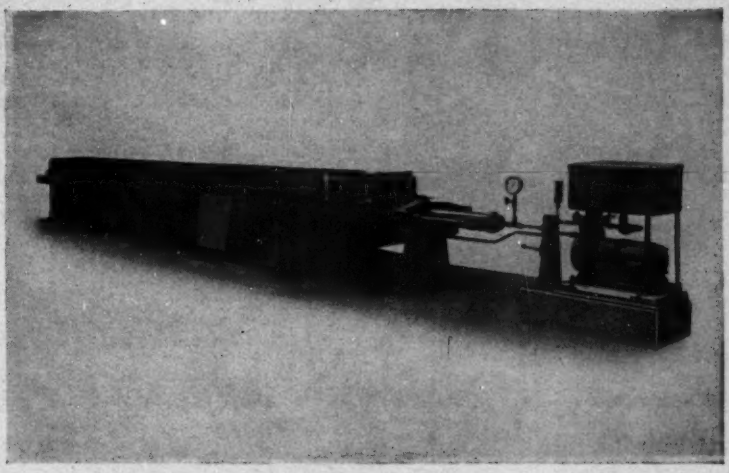

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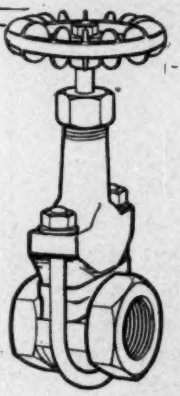

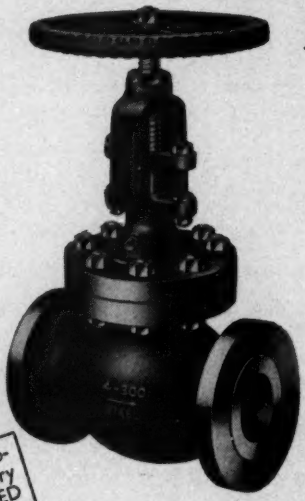

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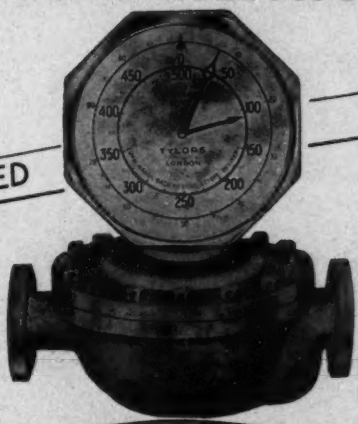

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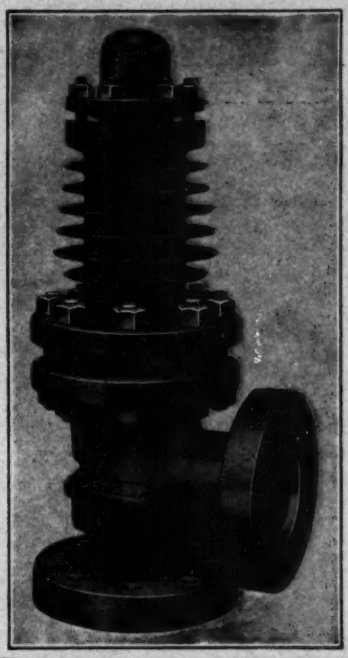

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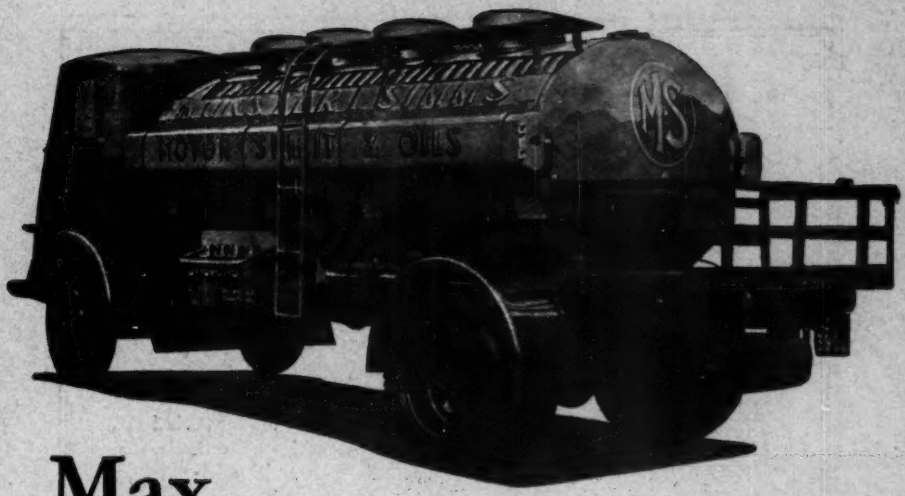

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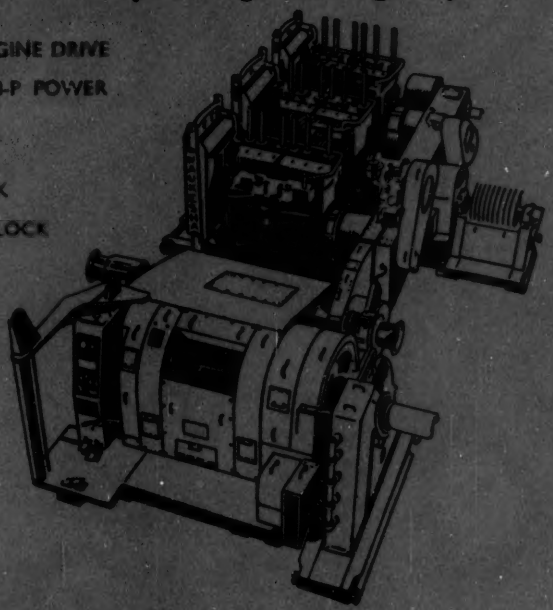

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